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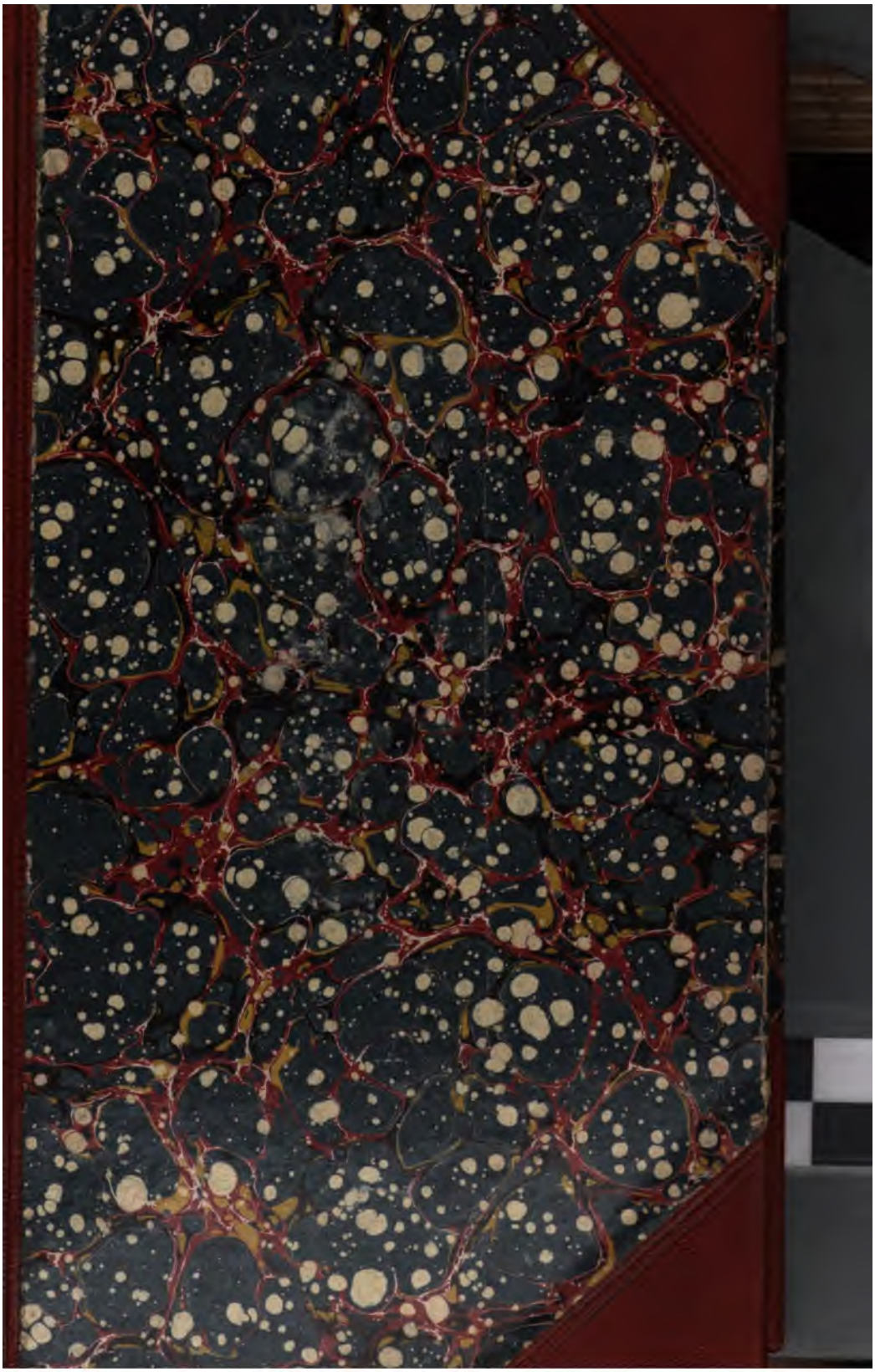

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

VOL. IV.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 1.] VOL. IV. [Session 1862-63.

The TWENTY-FOURTH ANNUAL MEETING of the Society was held at Three o'clock on Thursday Afternoon, October 30th, 1862, in the Museum, Peter Street.

In the absence of the President, E. W. BINNEY, F.R.S., F.G.S., one of the Vice-Presidents, occupied the Chair.

The Chairman, after explaining that the ordinary day for the meeting of the Society was Tuesday, and that the present alteration of the day was in accordance with the rules of the Society, which require the Annual Meeting to be held on Thursday, said,—We have before us a specimen of the *Pecopteris*, from the Gloucestershire coal-field. It has been kindly sent to us by Mr. Lynde, jun., and it seems to be a very fine specimen. I do not at present know to what species it belongs. It will be pleasing to the members to know that since our last Annual Meeting, we have had considerable additions to the number of members on our list. This week we have elected somewhere about fourteen new members, including His Grace The Duke of

Buccleuch, and Lord Stanley. The business of this meeting is solely of a routine character, and the first thing will be the reading of the Reports.

Curators' Report.

The Honorary Curators reported the receipt of the following donations during the year, viz :—

Fossils, &c.—A specimen of Stigmaria, or root of Sigillaria, in Gannister, from the neighbourhood of Sheffield, with rootlets shown proceeding from the thicker part of the root.—Presented by James Yates, M.A., F.R.S., F.L.S. F.G.S., &c.

Shells from the coal-measures, Little Hulton; and a specimen of *Trigonocarpon elongatum*, from Peel.—Presented by Mr. H. M. Ormerod.

Seven Mineral specimens from Cornwall, and a specimen of *Silicious Ash*, from a burnt stack of barley.—Presented by G. W. Ormerod, M.A., F.G.S., Chagford, Exeter.

A selection of Fossils and Minerals, from the collection of the late Wm. Peace, F.G.S.—Presented by his Sons, Messrs. Maskell W. and Charles O. Peace.

A specimen of Cannel, from South Wales.—Presented by the President, Jos. Dickinson, F.G.S.

A specimen of *Lepidostrobus ornatus*, and one of *L. comosus*.—Presented by Mr. Jos. Goodwin.

A collection of Fossil Fish, &c., from South America, and a cabinet of English Rocks.—Presented by Eddowes Bowman, M.A.

Specimen of Iron Ore from Sierra Leone.—Presented by Mr. Wm. Brooke, Brook Street, Manchester.

Books,—1. On the Vestiges of Extinct Glaciers, in the Highlands of Great Britain;—

2. The Geologist, No. 47;—

3. Map by the Government Geological Survey, of the District around Manchester; on a scale of six inches to the mile.—Presented by E. Hull, B.A., F.G.S.

4. The Proceedings of the Geologists' Association, from the commencement.—Presented by the Editor.

5. Mining and Smelting Magazine.—Presented by the Editor.

6. Journal of the Royal Dublin Society, for the current year.

Books,—7. Memoirs of the Literary and Philosophical Society of Manchester. Third Series.—Vol. I., 1862;—

8. Proceedings of the Literary and Philosophical Society of Manchester. Vol. II.—Sessions 1860-61 and 1861-62;—

9. Title page and Index, and one Sheet, viz:—p. 253—261, of Vol. I. of the Proceedings; with a plate of Jupiter's Disk;—

10. Copy of the Rules of the Literary and Philosophical Society of Manchester. The four last-named were presented by the Council of the Literary and Philosophical Society of Manchester.

11. Quarterly Journal of the Geological Society, for the current year.

12. A work on Cast Iron Tubing, to be used in sinking Shafts in Mines,—by Jno. Brown, Esq., Barnsley, Member of Institute of Mining Engineers.—Presented by the Author.

13. Proceedings of the South Wales Institute of Mining Engineers, for the current year.

14. Further Discoveries of Flint Implements in the Drift,—by John Evans, F.S.A., F.G.S.—Presented by the Author.

15. Journal of the Geological Society, Dublin.

16. Transactions of the N. of England Institute of Mining Engineers.

Report of the Council.

Since the commencement of the Session now about to terminate, your Council have the pleasure to announce that the Society has continued in a prosperous state, both in regard to the number of its members, and the activity that has been displayed by means of the papers read at the monthly meetings, and the discussions to which they gave rise. Twenty-seven new members have been elected in the course of the last session. A few have withdrawn. Five have died, viz., The Earl of Ellesmere; Captain Thomas Brown, (member ex-officio); John Evans, Esq., Royton; Mr. R. W. Barton, and Dr. Holden, of Haslingden. The last-named gentleman died in 1860, whilst engaged in an exploring expedition in the interior of Africa. A list of the names of new members, as well as of those who from death or other causes have ceased to be members of the Society, is added at the end of this report.

Two excursions were undertaken by members of the Society. The first was on the 7th of May in the present year, to the neighbourhood of Todmorden, an account of which has been given in the Society's Transactions. The second took place on the 3rd of September, in consequence of an invitation from members of the Geological and Polytechnic Society of the West Riding of Yorkshire, to the members of our Society, to meet them in the neighbourhood of Halifax, in order to examine the geology of that district, and to visit the celebrated coal and iron works at Low Moor. An account of this excursion will, in due time, appear in the Society's Transactions. These excursions were a source of much gratification to all who attended them, and it cannot be doubted but that all who took part in them thereby obtained in a very agreeable manner a considerable amount of valuable information. Your Council are of opinion that excursions of the kind here mentioned ought to be undertaken as often as can be done with convenience to the members, since they are convinced that no small portion of the healthy activity of any Geological Society must necessarily depend upon the interest which the individuals composing it take in making themselves practically and intimately acquainted with the geology of their own immediate neighbourhood, and of the surrounding districts.

In the course of the past year some valuable geological works have been added to the library; and additional accommodation for the books having been provided, it is hoped they will be found more easily accessible to those members who wish to avail themselves of the kind of information which they contain. Nine volumes of the works published by the Palæontographical Society have been bound, and thus these valuable books are now for the first time in a fit condition to be put into circulation among the members of the Society. Several periodicals hitherto existing in numbers or parts have also been bound; among these are twenty volumes of the Edinburgh Philosophical Journal. The following

is a list of the periodicals regularly received by the Society, either by purchase or exchange:—By purchase: Edinburgh New Philosophical Journal, American Journal of Science and Arts, The Geologist. By exchange: Quarterly Journal of the Geological Society, Journal of the Dublin Geological Society, Journal of the Royal Dublin Society, Memoirs of the Manchester Literary and Philosophical Society, Proceedings of the South Wales Institute of Mining Engineers, Transactions of the North of England Institute of Mining Engineers, Proceedings of the Geologists' Association, Mining and Smelting Magazine.

Your Council have great pleasure in stating that during the last session the attendance of members at the monthly meetings has been very good, and great interest has been manifested in the proceedings. A number of very valuable papers, both on mining and geology, have been read, some of which have, with our permission, been translated into French. A list of the papers read in the course of the year will be found appended to this Report. The third volume of the Society's Transactions has just been completed, in a part containing the title page, table of contents, and a copious index.

The Museum having recently been cleaned, and the fossils arranged and named by some of the most eminent palœontologists in the kingdom, may be stated to be in a highly satisfactory condition; and as it is open gratuitously to the public, your Council hope that it will be the means of affording useful and interesting information to a very large number of persons of all classes in this populous district. We hardly need add that to the student of geology a museum so extensive and well arranged will be invaluable.

Your Council may further state that they recently issued a circular to the landowners, manufacturers, miners, and cultivators

of science in the mining districts of Lancashire, Cheshire, and portions of Derbyshire and Yorkshire, setting forth the claims of this Society to their notice, and, in consequence, several noblemen and gentlemen have been induced to have themselves enrolled as members.

In conclusion, your Council beg to congratulate the meeting on the healthy and prosperous state of the Society, and to express an earnest hope that through the activity and zeal of both the mining and geological portion of its members it will continue useful, as well as prosperous.

LIST OF NEW MEMBERS ELECTED IN THE SESSION 1861-62.

Names marked thus (*) are Life Members.

Mr. O. A. Ferris, Victoria Park, Manchester.
Rev. Philip Graham, Turncroft, Over Darwen.
Mr. Maskell William Peace, Wigan.
Mr. Peter Pickup, Townley Colliery, Burnley.
Mr. John Cross, Gidlow and Swinley Colliery, Wigan.
Mr. Thomas Brooks, Sunnyside, Rawtenstall.
Mr. Benjamin Ashton, Pole Bank, Gee Cross, Manchester.
Mr. Ellis Lever, Bank Field Cottage, Manchester.
Mr. Peter Seddon, Dukinfield Colliery, Dukinfield.
Mr. William Buckley, Limehurst Colliery, Ashton-under-Lyne.
Mr. E. Hawksworth, Ladyshore Colliery, Radcliffe.
Mr. Joseph Roscoe, Chadwick Hall Colliery, Rochdale.
Mr. J. J. Horsfall, Fairbottom Collieries, Ashton-under-Lyne.
*Rt. Hon. Lord Stanley, M.P., Knowsley, Prescot.
Mr. Clegg Livesey, Bradford Colliery, Manchester.
Mr. William Beswicke, 20, Yorkshire Street, Rochdale.

Mr. W. H. Harbottle, Orrell Colliery, near Wigan.
Mr. Robert Knowles, Eagley Bank, near Bolton.
Mr. Oliver Heywood, Acresfield, Manchester.
Mr. James Roscoe, New Water Gate and Peel Hall Colliery, Little Hulton, near Bolton.
Mr. Martyn Seymour, Staveley Works, near Chesterfield.
Peter Spence, F.C.S., Alum Works, Newton Heath, Manchester.
*Mr. Eli Walsh, Hey Fold Colliery, Over Darwen.
Mr. Jos. Chatwood, Union Square, Bury.
*His Grace the Duke of Buccleuch.
Mr. Edward Wadham, Millwood, Ulverstone.
Prof. F. Crace Calvert, F.C.S., &c., Royal Institution, Manchester.

LIST OF MEMBERS WHO HAVE WITHDRAWN FROM THE SOCIETY IN 1861-62.

Rev. Geo. Perkins, M.A.
Ralph Fletcher, M.A.
Mr. Francis Charlton.
Mr. William Kellett.
Mr. Benjamin Ashton.
Mr. David Greenhalgh, Stubbins.

LIST OF MEMBERS WHO HAVE DIED DURING 1861-62.

Mr. R. W. Barton, 19, George Street.
The Earl of Ellesmere.
Captain Thos. Brown, M.P.S.
Mr. John Evans, Edge Lane, Royton.
Dr. Holden, Haslingden (1860.)

The following is a List of the Papers read at the Monthly Meetings of the Society in the Session 1861-62.

1.—On the Pleistocene Deposits, on the Stockport and Woodley Railway; by Mr. John Taylor, Jun.

2.—On the Ventilation of Mines; by Mr. Jos. Goodwin.

3.—On the Ventilation of Mines; by Mr. Jos. Goodwin.

4.—On the Self-Extinguishing and Detector Safety-Lamp for Working Miners; by Geo. Charlton, F.G.S.

5.—On the Bank Top and Hagside Pits; and the Proving of of Faults; by Mr. Andrew Knowles.

6.—On the Ventilation of Mines; by Mr. Jos. Goodwin.

7.—On Mr. Aytoun's Patent Safety-Cage for Miners; by Mr. J. J. Landale.

8.—On the Gases met with in Coal-Mines, and the General Principles of Ventilation; by Mr. John J. Atkinson.

9.—On the Friction of Air in Mines, &c.; by Mr. John J. Atkinson.

10.—On the Discharge of Air through Uniform Passages or Tubes; by T. T. Wilkinson, F.R.A.S.

11.—The Geology of the Railway between Hyde and Marple; by Mr. John Taylor, Jun.

12.—The North Staffordshire Coal-Field; by Mr. John Bradbury, Jun.

13.—On an Improved Safety-Cage for Miners; by Mr. T. Farrimond.

14.—An account of an Excursion to Todmorden; by E. W. Binney, F.R.S., F.G.S.

15.—Description of Water Balance Machines, used for winding Coals, Ironstone, &c. in South Wales; by Thomas Evans, F.G.S.

16.—Geology of Manchester and its Neighbourhood; by E. W. Binney, F.R.S., F.G.S.

MANCHESTER GEOLOGICAL SOCIETY.

BALANCE SHEET, 1861-62.

Abstract of Receipts.

1861.		£ s. d.	£ s. d.
Sept. 30.	Balance brought down.....		246 13 7
	Subscriptions, 1861-2, 113	113 0 0	
	„ 1860-1, 6	6 0 0	
	„ Half-year, 1862, 3	1 10 0	
			120 10 0
	Dividend on Stock.....		3 7 4
	Interest allowed by the Bank		8 7 2
			£378 18 1

Abstract of Payments.

1861.		£ s. d.	£ s. d.
Oct.	Library		10 8 6
	Reports of Meetings, &c.....		77 6 6
	Printing and Stationery		3 11 9
	Postages and delivery of Circulars..		18 18 7
	Collector's Commission		6 0 6
	Miscellaneous		0 8 6
	Purchase of £200 Stock of Birkenhead and Chester Railway.....		179 0 3
			£295 14 7
1862.			
Sept. 30,	Balance in the Bank	71 19 9	
	„ Treasurer's hands.....	11 3 9	
			83 3 6
			£378 18 1

Examined and found correct,
JAMES HERTZ, Auditor.

HENRY M. ORMEROD, Treasurer.

Mr. Alderman Harvey—Last year I had the pleasure of moving the adoption of these reports, and now I have equal pleasure in proposing "That the reports and balance-sheet as now read be adopted and printed for circulation among the members." I am very glad to find that the Society is in so flourishing a condition, and that it is receiving better support than it has hitherto received. I remember when we mustered in pretty good numbers many years ago, but afterwards we declined and almost became extinct. But, through Mr. Binney's exertions mainly, coupled with those of our secretaries and other gentlemen, I must say we gradually revived; and we are now become as important a society as ever—perhaps more important than we were before. The various articles and papers read from time to time at the monthly meetings of the Society have been exceedingly valuable, and they have gone forth, and have been the means of communicating a great mass of intelligence, not only to the general public, but in particular to geologists and miners. I am glad to see that in this point we are also progressing; and I hope that more scientific men will join us in this movement, and help us on in the good work in which we are engaged.

Mr. George Mosley seconded the resolution, which was carried unanimously.

The Chairman—As mention has been made of my name, it is only proper for me to observe that I am only one amongst others in working for the Society. But it is a good reward to see the Society so satisfactorily progressing, and it is encouraging to know that there is an increase, not only of members, papers, and contributions, but also a good balance,—for with us, as with all other societies, money is a great object.

It was moved by Mr. John Atkinson, and seconded by Mr. Bradbury, "That the thanks of this Society be given to the

respective donors who have made presents either to the museum or library during the last session."

The Chairman, in putting the vote to the meeting, said that the museum was by no means full, and there was still room in the library for any contributions which might be sent.

The resolution was carried unanimously.

On the motion of James Hodgson, C.E., seconded by Mr. J. J. Horsfall, the following Gentlemen were elected office-bearers for the ensuing year.

President:

JOSEPH DICKINSON, F.G.S.

Vice-Presidents:

EDWARD WM. BINNEY, F.R.S., F.G.S.
SIR JAS. P. KAY-SHUTTLEWORTH, BART., F.G.S.
MR. ANDREW KNOWLES.
MR. RICHARD FORT.

Treasurer:

MR. HENRY MERE ORMEROD.

Auditors:

R. P. GREG, F.G.S. | MR. JAMES HERTZ.

Honorary Secretaries:

JOHN ATKINSON, F.G.S. | MR. WM. ROBY BARR.

Honorary Curators:

E. W. BINNEY, F.R.S., F.G.S. | MR. H. M. ORMEROD.

Council:

MR. WM. BLACKBURNE,
MR. WM. BRYHAM,
PROF. F. CRACE CALVERT, F.R.S., &c.
R. D. DARBISHIRE, B.A., F.G.S.
MR. THOS. FARRIMOND,
MR. JOHN FLETCHER.
JOHN EDW. FORBES, F.G.S.
MR. JOSEPH GOODWIN,
PETER HIGSON, F.G.S.
JOHN LANCASTER, F.G.S.
MR. THOMAS LIVESEY.
MR. JOHN TAYLOR, JUN.

Also, E. W. BINNEY, F.R.S., F.G.S., and MR. ALDERMAN HARVEY were elected to be representatives of this Society at the Council Meetings of the Natural History Society.

The Chairman—Now you have been good enough to re-elect Mr. Alderman Harvey and myself as representatives of this Society at the council meetings of the Natural History Society, I wish to bring before you the fact that the circulars announcing the council meetings of the Natural History Society are never sent to us.

Mr. Alderman Harvey—The circulars in question have sometimes been sent to me.

The Chairman—At any rate they have never been sent to me during the last year, therefore I have not been able to attend the council meetings of the Natural History Society as your representative. If, then, I have not at those meetings done for this Society what you might fairly expect, it has not been from any want of desire on my part, but simply from the fact of my having never been invited by circular in the usual way. With regard to our own Society, I am glad to find that it appears to be in a thriving condition. Some time ago it was not so prosperous, and there was an attempt made to bury it. It was chiefly through my resistance of this attempt that it continued to exist as a distinct Society. Though through my efforts it continued to exist, it does not follow that what I did was the sole cause of its being kept up. The fact of its continued existence, as well as its flourishing state, is no doubt owing to the want felt in this extensive mining district for such a Society; but, at the period to which I have just alluded, it was greatly indebted to the assistance of many gentlemen who are still members; and it has been and still is in no small degree indebted to the zeal and efficiency of our honorary secretaries. For some years our present president gave his valuable services as one of the secretaries; but no one has done more in that capacity

than has been done during the last two years by Mr. Atkinson. The duties that have devolved upon that gentleman have rendered the office anything but a sinecure to him; for, in addition to the routine work and the correspondence, he has had to superintend the printing of our Transactions, involving of course the tedious duty of carefully reading and correcting the whole of the proof sheets. Mr. A. Knowles, who has been many years an honorary secretary, as colleague to the two gentlemen just named, has also done good service to the Society. He took the office when no one else would, and he has always done everything in his power to promote our success.

On the proposition of Mr. Alderman Harvey, seconded by Mr. Hodgson, a vote of thanks was passed to Messrs. Atkinson and Knowles for their valuable services as honorary secretaries during the past year.

Mr. John Atkinson, on behalf of himself and colleague, returned thanks.

The Chairman—There is no other business before the meeting; but I may mention that since the last meeting we have had an excursion to Low Moor, and Halifax. A notice of it will be given at our next meeting. I have also been in communication with Mr. Moreton, of the Liverpool Geological Society, and he expressed a wish that we should have a joint meeting of the Societies at Runcorn or somewhere near Wigan, with the view of having an excursion together. Some gentlemen in Yorkshire also suggested that the gentlemen of the West Riding and ourselves should have another meeting in their district. There are many suitable places, such as Penistone, Huddersfield or Settle, and the project, I think, would be a good one.

The meeting then terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 2.] VOL. IV. Session 1862-63.

The first monthly meeting after the summer recess was held at the Museum, Peter-street, on Tuesday afternoon, November 26th, 1862.

The President, Mr. Joseph Dickinson, F.G.S., and H. M. Inspector of Mines, stated that there had just been presented to the Society a publication entitled "Some Additional Observations on the Permian beds of South Lancashire," by Mr. E. W. Binney, V.P., F.R.S., and F.G.S.; and also, by the same gentleman, A Paper from the Quarterly Journal of the Geological Society (London), "On some fossil plants, showing structure, from the lower coal-measures of Lancashire," with very beautiful illustrative diagrams.

Mr. J. Atkinson, F.G.S. (hon. sec.), produced some specimens from Yorkshire sandstone flags, obtained in the neighbourhood of Halifax, on a recent excursion. The markings on the flags from which these specimens were taken, had been pointed out by several of the Yorkshire gentlemen as being made by "rain-drops," but it was very evident they were not so, as the markings, or perforations, had extended through the entire substance of the flags, which were three or four inches in thickness. These flags were easily split into thin laminæ, and the markings could thus be traced from one side to the other of the stone, plainly showing that

they had been made by worms of some kind when the sand was in a soft state on the shore of an ancient sea. Markings of this kind are very common in some rocks. There were hundreds of square yards of flags covered with them where these specimens came from; and these specimens themselves are not exhibited here as being fine ones of their kind, or as revealing anything new, but simply as showing most clearly that the markings on them have not been made by "rain drops," as surmised by several of our Yorkshire friends, who met and attended us on our late excursion.

Mr. Binney—These are very commonly found in the Catlow, Upholland, or Upper Lancashire flags. At Upholland they are far more beautiful than these, and distinctly show the holes the worms have made. Some years ago I published a description of the holes which are formed by the *arenicolæ* and these have been called *arenicolites* ever since. These, I should say, are not very good specimens. Since our last general meeting we have had an excursion to Halifax, and I have drawn up a short description, which perhaps it would be desirable to read to the meeting.

The President said he would first announce that Mr. Webster had been elected a member of the Society at the council meeting.

Mr. Binney then proceeded to read the following report:—

AN ACCOUNT OF THE EXCURSION TO HALIFAX, HIPPERHOLME, LIGHTCLIFFE, AND LOW MOOR.

An invitation having been given to the members of this Society by the council of the Geological and Polytechnic Society of the West Riding of Yorkshire to meet the latter at Halifax, on the

3rd of September, the honorary secretaries sent out circulars and made arrangements for the excursion. Owing to the unfavourable state of the weather, and other causes, there was not a large attendance of members; but at half-past eight a.m., a party consisting of the Hon. Secs. (Messrs. A. Knowles and Atkinson, F.G.S.,) Messrs. Binney, Horsfall, Parker, Hodgson, C.E., of Liverpool; the Chevalier N. P. Barbel de Morny, Captain of the Imperial Corps of Mines of Russia; and A. H. Green, M.A., F.G.S. of the Geological Survey of Great Britain, started for Halifax. At Todmorden they were joined by Mr. Pickup, of Wholaw Nook, Burnley, and Mr. Chatwood, of Bury. On their arrival at Halifax they were met by a deputation from the Yorkshire Society, consisting of Mr. Baines, of Lightcliffe House; Mr. Briggs, of Overton; Messrs. Wilson, O'Callagan, and Denny, F.L.S., of Leeds; Messrs. Leyland and Ward, of Halifax; Mr. E. Brooke, Jun., of Huddersfield; Messrs. Carter, C.E., and Richardson, C.E., of Barnsley; Mr. Richardson, of South Owram; and Mr. Ezra Woodhead, of Low Moor.

The party, by the kind permission of the officers, were allowed to examine the Natural History Society's Museum, which among many other valuable specimens, contains some of the finest examples of the genera *Goniatites*, *Nautilus*, *Orthoceras* and *Aviculo-pecten*, from the lower coal-measures that are to be met with in any collection. These specimens were obtained from the calcareous nodules, known by the name of "baum pots" found in the shale forming the roof of the hard bed of coal, which has been extensively wrought in the neighbourhood of Halifax. There is also a good collection of fossil coal plants.

We then went to the Swan Banks Colliery and saw the coals, namely, the soft and the hard beds now wrought there. The former is about 1 foot 5 inches in thickness, and lies about forty-five yards above the rough rock, the upper millstone of Professor

Phillips, and the Geological Survey. About twenty-six yards above the last named seam is the hard bed, near 2 feet in thickness, with a thin gannister floor, round calcareous nodules or bullions in the seam of coal itself, and black shales containing calcareous nodules, known by the name of the "baum pots," full of *Aviculo-pecten*, *Goniatites*, *Nautilus*, *Orthoceras*, &c. in the roof. The geological position, characters of the coal and its adjoining strata, as well as the fossil shells, all tend to shew that this seam is the same as the Bullion Mine of the Burnley district, and the Gannister Mine of Dulesgate, Todmorden. The lower mine, containing beds of *Anthracosia* under its floor, probably occupies the same geological position as the Bassy or Salts Mine of the Bury and New Mills districts. Besides these two seams there are several smaller ones which are not worked; and on the top of the hill the lower part of the Elland flagstone, the equivalent of the Upper or Upholland flags of Lancashire, is seen; so this series of coals lies between the rough rock and the upper flagstone, and is identical with that part of the lower called Rochdale series of coals in Lancashire.

On the summit of the hill we obtained an extensive view of the town of Halifax and its suburbs. We next called at the house of Mr. Richardson and examined his unrivalled private collection of fossil plants from the Yorkshire coal-field. Mr. Richardson explained his views of the nature of many of the ancient plants, and a whole day might easily have been spent in examining the collection, but our leader, Mr. Baines, was obliged to hurry us on in our course as laid down. We then examined the extensive flagstone quarries of Hipperholme and South Owram, and saw flags of four and five yards square being lifted. These stones, under the name of Yorkshire flags, are known all over England. We arrived at the hospitable mansion of our worthy host at one o'clock; and after partaking of the good things which Mrs. Baines had so amply provided for us, at two o'clock we started by rail to Low Moor.

On reaching this place the party divided itself into two groups, one of which, under the guidance of Mr. Baines, was introduced to the partners of the Low Moor Iron Company, who kindly accompanied the party through their extensive works, and explained to them the manufacture of their celebrated iron; and the other, under the leadership of Mr. Ezra Woodhead, went down into the mines and examined the Better Bed coal, and the Black Bed coal with its overlying bands of ironstone. The lower, or Better Bed, is a coal of most excellent quality, but only about sixteen inches in thickness. It is exclusively used for making coke to smelt the iron ore. The Black Bed lies some forty yards above the Better Bed; it is from thirty to thirty-five inches in thickness, but it is very inferior in quality to the Better Bed; over it are about four inches of clay band ironstone, in four or five layers, dispersed through 4 feet 6 inches of black shale. This stone, after having been mined, is for a long time exposed to the action of the atmosphere, and carefully turned over, handpicked, and dressed before it is roasted. After the stone has been thus treated the requisite quantities of coke, (made exclusively from the Better Bed) and limestone are added, and the whole is smelted by cold blast; thus a pig iron is produced, from which the well known Low Moor iron is manufactured. Here is the secret of the manufacture of good iron; great care in the selection of a good coal, free from sulphur and other impurities for making coke; and the like attention to the quality, cleansing and preparation of the clay-ironstone before it is subjected to the heat of a cold blast furnace. Besides the Black Bed an ironstone, known by the name of the White Bed mine, and lying some distance above the former, is used, but we did not examine it *in situ*.

The position of the Low Moor seams of coal and their accompanying ironstones, is immediately above the Halifax series of coals and its overlying bed of flagstone, as seen at South Owram, strata

not well developed in the Lancashire coal-field, although there represented near Heywood, between the upper flag deposit and the Arley or Dogshaw Mine.

The following is the analysis of the Black Bed mine.*

Protoxide of Iron	36·14
Peroxide of Iron	0·61
Protoxide of Manganese	1·38
Alumina	0·52
Lime	2·70
Magnesia	2·05
Carbonic Acid	26·57
Phosphoric Acid	0·34
Sulphuric Acid	trace.
Bi-sulphide of Iron	0·10
Water Hygroscopic	0·61
„ Combined	1·16
Organic Matter	2·40
Insoluble Matter	25·27
	99·85

Insoluble Residue.

Silica	17·37
Alumina	6·22
Peroxide of Iron	0·84
Lime	trace.
Magnesia	0·12
Potash	0·65
	25·20

The composition of the ironstone differs little from the ordinary clay-ironstones of the Yorkshire and Derbyshire coal-measures, certainly not so much as to account for the price and quality of the

*Memoirs of the Geological Survey of Great Britain, and of the Museum of Practical Geology. The iron ores of Great Britain.—Part I., p. 70.

iron made from the former, when compared with that made from the latter; therefore it is pretty evident that the pure quality of the coal, and the great care bestowed in cleansing and treating the iron-stone are the chief causes to which the superiority of the iron must be attributed.

The party dined together at the Inn, near the Railway, and after spending a very pleasant evening, returned to Manchester by the late train, highly pleased with their day's excursion. An opinion was expressed by members of both Societies that it was desirable more of such mutual meetings should be held, as they could not fail to be of advantage to both Societies. A meeting might be held at Settle, to examine the bone caves of that district; another at Ingleton, to inspect the interesting permian deposits of Westhouse, the singular coal-field of Black Burton, the mountain limestone and silurian beds of Thornton Gill, and the dykes of Chapel le Dale; and a third at Hazlehead, on the Manchester, Sheffield and Lincolnshire Railway, to examine the lower coal-measures seen between Dunford Bridge and Penistone. These are only a few of the many places where both Societies might meet in the field, and investigate the geological structure of the districts visited.

Mr. Richard Fort, of Read Hall—Is your identification of these Hipperholme flags founded upon the lithological character of the flags generally, or upon any fossils found in them?

Mr. Binney—It is founded on the lithological character of the flags, their position with regard to the middle and lower coals; and also that of the fossil shells found under them.

The President—The neighbourhood of Ingleton would be a very interesting place to visit.

Mr. Fort: I am told that there are some bone caves near Settle, flooded at present. If you have any excursions in the spring, you might visit them.

Mr. Binney—I have heard of their being locked up, and people prohibited from going into them and examining them.

Mr. Fort—The cave question is now likely to increase very much in interest, and a visit would be highly useful. Who locks up these caves?

Mr. Binney—The owner, I believe. But Mr. Atkinson, our secretary, has made a further account of our excursion, and perhaps he would now be good enough to read it.

Mr. Atkinson—I ought first to explain, perhaps, that when we went to Low Moor we divided into two parties—one party went through the coal works, and the other through the iron works. I do not profess to enter into the science or details of iron making. my object being merely to relate what. came under our personal notice at the time, and such as would strike the attention of ordinary visitors. Mr. A. here read a short description of the visit to the foundries and workshops of Low Moor.

The President said that as a paper was about to be read by Mr. Joseph Goodwin on "the Long-Wall, *versus* the Pillar and Stall system of working coal," the meeting had better not discuss any questions which might arise out of the interesting accounts just read by Messrs. Binney and Atkinson.

Mr. Spence—I think we ought first to acknowledge the reports

which have just been read to us, and I will therefore propose a vote of thanks to Mr. Binney and Mr. Atkinson for the very admirable accounts they have presented us with of the excursion. As a young member I am not able to say much, and also because, although a great admirer of its truth, I am but little acquainted with geology. But I do know something of the descriptions given in these papers, and I think they are exceedingly important. I visited these works myself some time ago, and was highly gratified and much interested with the mode of working the iron for producing that high quality for which they are celebrated. It seems to me a consideration of great importance that, as Mr. Binney has stated,—and no one knows these facts better than he does,—that the ore is similar in quality to other clay-ironstone, and that the superiority of the Low Moor iron arises solely from the superior care bestowed upon the various processes of its manufacture.

Mr. A. Knowles seconded the vote of thanks to Messrs. Binney and Atkinson, which was carried unanimously.

Mr. Joseph Goodwin read the following paper :—

LONG-WALL *versus* PILLAR AND STALL SYSTEM OF GETTING COALS.

In consequence of so much having been said from time to time upon the relative merits of the two systems of working coal, I am induced to lay before you a few facts and observations in as brief a form as is consistent with the importance of the subject under consideration. First remarking that all must be agreed as to the importance of adopting the system that will admit of the greatest per centage of round or hand filled coal and the greatest yield per acre, whilst affording to the workman the greatest security from

accident and the capitalist from losing his property. To say that any one system possesses all these much to be desired advantages, under all circumstances, is more than I dare affirm. That the long-wall system possesses advantages over the pillar and stall, under some circumstances, is an indisputable fact. While on the other hand it is simply impossible to work some mines to advantage upon the long-wall system, however skillfully the workings may be conducted. Perhaps the most important advantage in the long-wall system is, that all the coal may be worked out without the slightest waste; this cannot be said of any other system. If we take the loss to be 5 per cent. with the pillar and stall system, which is certainly below the mark, and call the mine rent 10d. per ton, it at once lessens the profits ½d. per ton, which upon 300 tons per day or 93,600 tons per annum yields the sum of £195 or a sum equal to that of a manager's salary in some instances. If the rent or royalty is only paid upon the quantity of coal sent to the bank, as is sometimes the case, then the loss is removed from the lessee to the lessor; it nevertheless remains a loss. I need hardly observe that if only 5 per cent. is wasted in working the coal it involves a loss to the capitalist of one twentieth of the capital expended in sinking shafts, erecting machinery, &c. The loss from this source is a considerable item, where due attention and skill is directed to the working of coal upon the pillar and stall system, and only the minimum of 5 per cent. wasted in working. But if, as is often the case, the loss or waste exceeds 10 per cent. the loss must be ruinous to the capitalist. It can excite no wonder in the minds of those who have carefully considered the subject, that collieries so worked should fail to answer the expectations of the proprietors; but this cannot fairly be charged to the system, but to the defective manner in which it is carried out. If we consider this loss or waste in a national point of view, it will not be of much less importance to the whole community or future generations than it is to the proprietors of mines who sustain a direct pecuniary loss. For although there may be no fear of the coal of the United Kingdom

being exhausted for a couple of centuries, and in the meantime substitutes may be discovered that will lessen its consumption and render the nation much less dependent upon it than at present. It, however, cannot have failed to have occurred to all who have carefully considered the subject, that before another century has passed over, coal will not only be far more difficult to work owing to the increased depth at which it will have to be wrought, but that some of our existing coal-fields will have been worked out and many others reduced to very narrow limits.

The long-wall system has produced a greater per centage of round coal in every case that has come under my own observation than that of any other system. But the most striking advantage that I have yet seen is in the Three Quarters Mine at Clayton Colliery. This mine was formerly worked upon the long-wall system, but by some means it was discontinued, and for about twelve months it was worked upon a modification of the pillar and stall system, during which time the per centage of round coal was only twenty-eight. For six months subsequent to that period, and for six months previous the per centage of round coal was over eighty-five. I am quite aware that much difference exists in the same seam of coal within a very limited area, and that a much greater per centage of round coal may be produced from different parts of the same mine with precisely the same system of working, and that this circumstance renders it somewhat difficult to arrive at a fair estimate of the difference of the two systems. But in the case referred to no such difference existed.

In an experiment in the Roger Mine, Haughton, the difference in the yield of round coal was 4¼ per cent. being in favor of the long-wall system. The experiment was fairly conducted and extended over the working of ten thousand tons of coal; in this case the advantages were more than counterbalanced by the

difficulty experienced in keeping good the wagon roads, and the long-wall system was abandoned for a modification of the system.

The Peacock Mine, Hyde, furnished more favorable results than the Roger Mine, Haughton, in experiments sufficiently extensive to test the relative merits of the two systems. These are not the only mines wherein I have made direct experiments, but I have selected them simply because one furnishes us with an example most favorable to the long-wall system, so far as producing a greater per centage of round coal. While the advantage from the same source in either of the other mines is such that it may easily be counterbalanced by disadvantages of another kind. The mines referred to will in all probability be well known to most present, but as they are not always found in the same form, it may not be amiss to offer a brief description of them.

The Three Quarters Mine varies from 20 inches to 2 feet in thickness, and rests upon a floor containing many nodules of ironstone, which renders it somewhat difficult to hole or undermine the coal in floor. The roof is a strong grey metal, suitable for walling or building packings with; the angle of inclination is about 20°.

The Roger Mine is 4 feet in thickness, and reposes upon a coarse fire-clay. The roof is a strong metal with rock binds, but it is very irregular, sometimes being difficult to keep from falling, and at others being one of the best of roofs; the angle of inclination is about 28°.

The Peacock Mine is about 2 feet 6 inches in thickness, and is one of the most fiery seams in the South Lancashire coal-field. This mine is known in the neighbourhood of Oldham by the name of Bent Mine; it rests upon a floor composed of alternate layers of shales and thin seams of coal. The roof is composed of tender

shale for about eighteen inches in thickness, above which, a strong dark colored metal is found. The roof of this mine perhaps contains more fossil plants than any other in the district; the angle of inclination is about 35°.

In working the coal upon a properly conducted system of long-wall working, where the mine is adapted for such system, there can be little doubt but that the risk of accidents from falls of roof is materially lessened. In my own experience I have never had the slightest accident from such source, where the long-wall system has been practised. We, however, ought not to overlook the fact that some mines are naturally more dangerous to work than others, and that the danger often increases in proportion as the thickness of the seam increases, assuming that all other circumstances remain the same, and that as a rule, it is the thinnest seams that are worked upon the long-wall system. The ventilation is far more simple in long-wall working than in pillar and stall, besides which, the health of the workman is not so impaired by driving narrow or strait work, this being in a great measure dispensed with. To those familiar with practical mining it must be evident that not only is greater physical power required in driving narrow work, but that the atmosphere of the mine is much less pure where the increased physical energies have to be brought forth. I have myself worked in places where the air has been so vitiated that it is now a matter of surprise to me how the constitution should have been able to have resisted such life-destroying agencies. I admit that an improvement has taken place of late in this respect, but it is yet no uncommon thing for men to work in a level or heading forty or fifty yards beyond the point where the air circulates, and this too in an atmosphere sufficiently impure to produce the worst possible effect upon the constitution of the most robust. If the seam be a fiery one, and the colliery well regulated, a current of air will be conducted to the working faces by means of bratticing, but that can only be done at considerable cost and inconvenience, and

must consequently be put down as an item against the pillar and stall system. I will not undertake to say in how many cases the safety-lamp is used as a substitute for ventilation in driving narrow work, but I may observe that if the health of the workmen was considered the cases would be much less numerous than at present.

Another advantage that I shall claim for the long-wall system before speaking upon the other side of the subject is perhaps of more importance to those who unfortunately spend most or all of their capital in sinking shafts, erecting machinery, &c. than those already mentioned. It is the advantage of being able to dispense with the necessarily large outlay consequent upon driving narrow work in a systematic manner preparatory to working back the pillars, and thus securing a return for the capital expended in the least possible time. I am quite aware that there are both managers and proprietors that do not wait for the levels or headings to be driven to the boundary before they begin to work out any coal that they may deem eligible, regardless of ulterior consequences, system, or order. I have seen many instances where this want of system has prevailed, but in no single case has it been attended with anything but ultimate disappointment and dissatisfaction to all concerned. The North of England may be considered as the parent of the pillar and stall system, but it is now more or less used in almost every coal-field in Great Britain as well as upon the continent. If it possessed no advantages over the long-wall system, the mining engineers who adopt its use might reasonably be considered very prejudiced men. That epithet has been lavishly applied by some of the advocates of the long-wall system to those who continue the use of the pillar and stall system, forgetting that they lay themselves open to the very same charge by adhering too rigidly to that which they believe to be the best. For my own part I deem it best to carefully examine into every circumstance connected with a mine before adopting any system, and after so

doing I will not say that I might not err in judgment. The pillar and stall system will admit of an almost unlimited quantity of coal being daily worked from the same area that would only admit of a very limited output if the long-wall system was used. I need hardly remark that with many this is an advantage that must weigh much in favor of the pillar and stall system; although for my own part I confess that I am not an advocate for raising very large quantities where a smaller quantity with judicious management would produce a better profit. With the pillar and stall system the workings may be conducted any reasonable distance upon the line of level, the only limits being the increased cost of conveying the coal to the pit's eye, and the difficulty of thoroughly ventilating the workings owing to the increased drag or resistance that has to be met in conveying currents of air through long air-courses.

With the long-wall system the case is very different; for owing to the difficulty and expense of keeping good the wagon and air-roads, the distance is practically limited in many mines to a few hundred yards. The greatest distance on the line of level that I have known to be worked out upon the long-wall system is rather more than eight hundred yards; and in the case referred to it was very expensive to keep the wagon roads so that the coal could be brought along them, owing to the constant creep of the floor, and the wagon road rails having to be repeatedly taken up and lowered. In some instances the difficulty of keeping the main wagon roads in order is increased from want of skill. I have a case at point where it was very difficult indeed to maintain a wagon road, although it was little more than a hundred yards in length, and at that point it became a question for serious consideration whether to abandon the workings or continue them upon some different principle. It was, however, ultimately arranged to try a few yards farther upon the long-wall system, but instead of only working out four yards below the bottom wagon road to work out

whether the coal be worked on the long-wall or pillar and stall systems, providing equal skill is displayed in laying out the workings, &c. While the cost of getting depends so much upon circumstances that it is unsafe to hazard an opinion in favor of either system, unless both have been employed in the same mine, under very similar circumstances; and, even in the cases where I have adopted that course, I have sometimes found the results in favor of the pillar and stall system, and at others *vice versa*. It is possible that I may have omitted touching upon some points that might have been introduced into the subject to advantage. If so, it has not been from any desire to lay the matter before you in anything but a candid manner, that such omissions have been made, but simply because nothing more occurs to me as being necessary to show that both systems possess their advantages; and that it is unwise to confine ourselves exclusively to any one system. It may be that occasionally some other system will answer better than either of the systems under consideration, for we by no means embrace the whole of the systems of getting coal when we speak of the pillar and stall and long-wall, although many of the methods of working coal are but modifications of either one or the other of the systems spoken of.

The subject was illustrated with two diagrams, one representing the long-wall system; the other the pillar and stall.

On the motion of Mr. Binney, seconded by Mr. W. Blackburne, the thanks of the Society were given to Mr. Goodwin for his contribution.

The President announced that the subject was open to discussion.

Mr. Thomas Knowles—May I ask how you arrived at your conclusion that there was a loss of 5 per cent. in working the pillar and stall system? I have had something to do with the working of that system for some years, in fact I have never worked any other, and I must confess that my opinion is that it is better under ordinary circumstances than the long-wall. I should very much like to know how you arrive at a loss of 5 per cent.

Mr. J. Goodwin—Well, I believe that is generally allowed in computing the average; but I may state that I myself have seen more than 10 per cent. lost with careful management.

Mr. T. Knowles—Probably you have. But why should it be so? Of course any quantity may be lost by imprudent management. But my question is—how does Mr. Goodwin arrive at the conclusion that there is a loss of 5 per cent. in working the pillar and stall system?

Mr. Goodwin—I arrived at the conclusion partly from experience and partly from data furnished by nearly all the mineral surveyors in the county. I am at this time acquainted with a mine which I defy any person to work at less than 10 per cent. loss on the pillar and stall system.

Mr. T. Knowles—But I am speaking of mining generally, and not of one mine in particular.

Mr. Goodwin—It is of mining in general that I speak when I mention 5 per cent.

Mr. T. Knowles—Mr. Goodwin says that his reason for supposing there is less breakage, or more per centage of round coal, in work-

ing the long-wall system, is because he works 10,000 tons on the pillar and stall system. Now, does he suppose that that is sufficient to give the system a fair trial as to whether he can get a fair per centage or not? I have an idea that the mere excavation of 10,000 tons is not sufficient.

Mr. Goodwin—I think it furnishes very excellent data to work upon. And this is by no means an exceptional case. I don't mean to say I confine myself to 10,000 tons, but I wished to speak of what I knew, and happening to have these honest facts in my possession, I thought it best to lay them as such before you. I could mention a mine where the per centage is from 25 to 28 in favor of the long-wall system, independent of the before mentioned cases.

Mr. T. Knowles—There is a wonderful difference between excavating 10,000 tons of the solid coal, and working out 5,000 or 6,000 in wide work. Then you will find there is such a weight on the coal that it has a tendency to crush it, and you will get a different per centage.

Mr. Goodwin—In working we build a packing on each side of the wagon road, varying in width from six feet to three yards, as the nature of the work might require. We make a wagon road the same as on the pillar and stall system, and the only difference I have experienced in any of the mines I have yet tried is in the creep of the floor. I am not quite certain whether this difficulty could not be overcome by blowing down the roof.

Mr. T. Knowles—Do you mean to say that the packing keeps the whole of the roof?

Mr. Goodwin—Most certainly I do.

Mr. Fort—What is the area kept up by this packing?

Mr. Goodwin—Say 800 yards on line of level, and 150 yards on the rise and dip in the plan now before you. But I have known the workings to extend 1400 yards from the two extreme points, with 150 yards of rank or width from the rise to the dip of the workings.

Mr. A. Knowles—How many walls are there in 100 yards in breadth and 200 yards in length?

Mr. Goodwin—The walls are built at various times, as the coal is worked out; and we keep the walls in the line of level, and take them with us. The roads are 20 yards apart, which I find to be the most convenient distance. We have occasionally packing between, if desirable.

Mr. A. Knowles—And will that amount to sufficient to support all the strata to the surface?

Mr. Goodwin—Yes, it does.

Mr. Farrimond—I think it is an impossibility.

Mr. Fort—What is the thickness of the strata?

Mr. Goodwin—250 yards. After you get a certain distance you do not experience any of the weight just now referred to.

Mr. T. Knowles—It is a new theory to blow the roof down in order to let the warren lift. It is a theory I do not understand. There is no practice in that kind of work.

Mr. Goodwin—When I advanced the theory, I simply stated that it was an opinion of my own, but whether it is feasible or not I cannot say. I don't profess to be infallible, and I merely say that I shall try it.

Mr. T. Knowles—Well, it is rather an expensive process.

Mr. Binney—I think we are much obliged to Mr. Goodwin for bringing a novelty before us, for evidently the long-wall working seems to be a novelty in Lancashire. All these questions become more interesting from being discussed at a Society like our own. I have no doubt there will be more advocates for the pillar and stall system in Lancashire than the long-wall. Nevertheless, I am glad to see that Mr. Goodwin does come forward and say something in favor of long-wall working. If the Lancashire gentlemen went into North Derbyshire probably they would find a great many advocates of the long-wall system, and they would see advantages there which they do not see in Lancashire. The same remark will apply to the East of Scotland. I have a great idea myself that the different systems of long-wall and pillar and stall workings will have advantages in particular districts. I think in Derbyshire, where the long-wall system has been going on for 150 or 200 years, the men are so thoroughly drilled to it, and work it so scientifically, that its results would hardly be fair as applied to us. You would doubtless be a very long time in Lancashire in getting your men to work so well at it as they do in Derbyshire. On the other hand, and on the same principle, you would have a difficulty in introducing the pillar and stall system into Derbyshire.

In Scotland they all use the former, and they say they can get a great deal more coal by it. I have a little colliery of my own there, and I am tied down by lease to work it upon the long-wall and no other system. They imposed upon me the necessity of doing this, although I would willingly been allowed a choice. What I saw in Derbyshire, and what I see now, is that they certainly get cheaper and larger coal than in Lancashire. There may be peculiarities in the field, and in the nature of the roof, which give them some advantage; but I think it is not impossible that there may be many seams of coal in Lancashire which the long-wall would work with success.

Mr. T. Knowles—I find from enquiries which I have made, and also from going into Derbyshire, that we get our coals cheaper than they do in that district. The Lancashire colliers in Derbyshire will not work the long-wall system. We get our coals in Lancashire, as a rule, considerably cheaper per ton than in Derbyshire, where they adopt the long-wall system.

Mr. Binney—I think the Derbyshire people would decidedly object to that statement.

Mr. T. Knowles—I think not, sir, for I have been told differently. At the same time I concur with you that there are mines in Lancashire that are worked upon the long-wall system with advantage, particularly the thin mines.

Mr. A. Knowles—Referring to ventilation, may I ask whether Mr. Goodwin ventilates the goaf?

Mr. Goodwin—No.

Mr. A. Knowles—And do you not apprehend danger from the gas?

Mr. Goodwin—Not the slightest.

Mr. T. Knowles—I have had the management of collieries for 15 years, during which time we have only had one fatal accident; and it has all been pillar and stall work.

Mr. Binney—But in the neighbourhood of Wigan there have been a good many accidents. If you take the long-wall system in Derbyshire and Scotland you will find that they have never had such accidents as with the pillar and stall system generally.

Mr. P. Higson (inspector of mines)—The best proof that can be given of the merits of the long-wall system is that there are several mines in Lancashire now worked on the long-wall system with profit, which could not be worked at all with the pillar and stall system. There are also many others in Wales.

The President—It was evident that the preponderating feeling amongst the viewers of Lancashire, as far as they are represented by this meeting, is in favour of the pillar and stall system. I myself was brought up in the North of England, and I thought then there was nothing like the pillar and stall system. But during the last 22 years I have been constantly more or less in districts where the long-wall system has been followed, and I find that the advantages of that system have grown upon me year after year, and it is now many years ago since I arrived at the conclusion that of the two systems the long-wall is incomparably the better. It possesses many advantages; and although Mr. Thomas Knowles may have given us the result of his experience at Wigan, where he has carried on some mines in the most successful manner, I do not think we

should be led away from the advantages of the long-wall system simply because he by means of the other is able to produce equally beneficial results. In Lancashire the best methods may be said to be a combination of the pillar and stall system and long-wall. Pillar and stall, so far as driving to the extremity of the boundary is concerned, and then bringing the coal back by long-wall, or semi-long-wall, and pillar and stall. There are places where the waste is not only more than 5 per cent., but I know of my own knowledge that there is actually in thick and tender seams in South Wales one half of some of the best steam coal in this country being left in the ground, crushed, spoiled, and irrecoverably lost. That is by pillar and stall work, whilst in the same colliery I have taken comparative results of the coal got by the long-wall system, and I can state that almost the whole of the coal was obtained, and scarcely any lost. These points to which Mr. Goodwin has alluded may appear different to those who have not really gone practically into the subject of the long-wall, especially what was called his new theory of taking down the roof to make room for the wagon way to lift. There are many long-wall collieries where it is decidedly the better way not to cut the bottom at all. Cut down the roof until you have all your ground settled about you, and you will soon have as permanently settled a road as if it had been cut into the solid coal. I have seen this over and over again; and if you will go into some of the mines in Shropshire, where long-wall is universally practised, you will see what I mean. There is no other system practised there. In South Staffordshire there is scarcely any other system except in the 10 yard coal, which is worked to a great extent by pillar and stall, and in a most wasteful way. In some parts of Derbyshire, or in the Clayton colliery at Manchester, for instance, you will see long-wall carried out successfully; and it appears that at Clayton Mr. Goodwin has noticed the very same thing which I have noticed in other places. In Scotland, most of the ironstone and coal mines are conducted upon the long-wall system, and we all know that no men go more minutely

into the matter of £. s. d. than Scotchmen. Mr. Binney tells you that there he is actually compelled to work his colliery long-wall work. I have myself seen thick seams in the South of France worked by the long-wall system. I have there seen a seam 80 feet thick worked in this way. It may be easier to work a thin mine long-wall work, but it is not impossible to work thick mines long work, and I believe quite as successfully as working them the other way. Mr. Goodwin's paper touches on many other points, all of which have a most important bearing. In the long-wall the ventilation is carried exactly where it is wanted, whereas in the pillar and stall you are dependent upon cut-throughs, bratticing, or other methods, all less certain. With regard to the question of safety, I have never seen any comparative results of the number of accidents as arising from the two systems, but I believe if they were compared together you would find that the result is considerably in favour of the long-wall. In Scotland the number of accidents is exceedingly small, as compared with our own accidents. In Derbyshire, accidents are few; in Shropshire few. In South Staffordshire they are more numerous, but that is because of the thick coal worked on the pillar and stall system. I believe, if you take the whole country round, you will find that the waste in pillar and stall working—that is, where the real pillar and stall, and not a combination of the two, is practised, as in Lancashire—you will find that the waste is very great, that a larger proportion of small coal is produced, and that a large proportion of very valuable mineral is lost, of which sooner or later this country will have to feel the ill effects. We are working very fast over some very valuable seams. In large tracts all over the country they are being rapidly removed. The best seams at shallow depths are fast going away. I believe that the long-wall system was introduced into the Manchester district by the late Mr. Bradbury, several years ago. He was a gentleman conversant with both systems, and had mines in Staffordshire worked by the long-wall system. He saw the advantage of that system as compared with the other, and he introduced it

here. I am glad to find that Mr. Goodwin has extended it into the Peacock mine. There are several other points upon which I would like to touch, but our time is too limited.

Mr. P. Higson—I have seen on a large scale the long-wall system carried out almost to perfection. I have seen on a similar scale the long-wall well carried out in the neighbourhood of Wigan, in the present day. In the yard coal, in the cannel, and in other thin seams, the system has been carried out quite successfully; while it failed elsewhere, although tried by the same people. They failed from the fact that there was an overwhelming weight in the place, thereby crushing the coal into small. With regard to these two systems, as shewn on the plans, they are now carried out in two collieries in my district side by side. There is one under the arrangement of a north country viewer. The quantity of small is equal in both, while that gives the larger outlet which provides more working places for the men.

Mr. T. Knowles—I still contend there is no occasion to lose 5 per cent. in any mine.

Mr. Binney—This battle of the walls is a good one, and I should like you to give us a paper on the advantages of the system pursued at Wigan.

Mr. Farrimond—I have never seen 5 per cent. loss, and I have gone over a great many mines worked by the pillar and stall system. With regard to the small coal, it must be remembered that it often results from the use of the pick.

Mr. P. Higson—We must all admit that clean working is in favor of the long-wall system.

Mr. Goodwin—I grant that this is a subject upon which we cannot but have erroneous ideas if we have only made our observations in one locality. The cost of getting coal depends so much upon the circumstances by which you are surrounded that you cannot compare it to any other district. With regard to the safety of the workmen, I say they are safer with the long-wall system, because there is no breaking down of the works.

A conversation then took place between Mr. Goodwin and Mr. Knowles. The latter gentleman doubting the opinions given by Mr. Goodwin on the subject of angles.

The President—It would be much better if gentlemen would say what they have to say in a somewhat connected form, otherwise it will be impossible to place what is said upon the record of the Society, and we should thereby perhaps suffer loss. We have many mines in this county, for instance the Cannel about Blackrod, and also some thin seams, which are worked long-wall; whereas they were once worked on the pillar and stall system. All that narrow work is now saved; and it is only about a month ago since I had one of the large coal owners of South Wales seeing me, and he has some of the most extensive and the deepest steam coal mines in the Aberdare district. He wished to introduce the long-wall system; so satisfied is he of the advantages it possesses over the old pillar and stall system. But in South Wales they are not only proposing, but now in some cases are actually working on the long-wall system. Possibly the heading of this paper, "Long-Wall *versus* Pillar and Stall," has something to do with the antagonism set up against it. I do not see that there is any antagonism existing between the two systems. The long-wall system, is adapted to a great number of seams. Through the whole of Belgium to depth of 940 yards there is no other system followed. In that country the engineers, from the results of practice

E

Wasdale Crags
Shap Wells
Greenrigg
Old red Sandstone
Metamorphic Green Slates
Shap Granite
Hard deep blue limestone
Dark red Sand-Stones and coarse conglomerates
Composed of crystals of Felspar, Quartz, and Mica with large ones of Red Felspar predominating

William Morton, 88 & 3 Bridge St, Manchester

and consultation, have come to the conclusion that it is *the* syst and therefore they adopt it. And we also are gradually introduc more of the same system, which has been the system of som our counties from time immemorial. I believe there is as li loss of coal generally in working the Lancashire coal mines, as th is to be met with in any district, but that is owing to combination of these two systems.

Mr. Goodwin—I grant there is deep-rooted prejudice against t system. I have experienced some of it myself in introducin as I have into six different mines in different parts of the coun I have only to add that I shall be most happy to afford any info ation upon the working of the long-wall system.

A vote of thanks was unanimously given to the Chairman ; t the proceedings terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 8.] VOL. IV. Session 1862-63.

The monthly meeting was held in the Museum, Peter Street, on Tuesday, December 30th.

In the absence of the President at the earlier part of the meeting, E. W. BINNEY, F.R.S., F.G.S., took the chair.

The Chairman said that the members present would see on the table two very good specimens of *Lepidodendron*, in coal shale, from the Haughton Collieries, and also two specimens of coral from the drift at Norbury, in Cheshire, the whole having been presented to the Society's Museum, by Mr. Joseph Goodwin. The coral specimens were, he observed, particularly good of their kind. They had come out of mountain limestone, fragments of which having been mingled with the drift, the substance of the stone had been eaten away, probably by carbonic aid, and the corals were freed from the matrix and left quite distinct and perfect,—a state in which it was not common to meet with them among the mountain limestone rocks themselves.

It was announced that Mr. John Stewart, Dunkenhalgh Park Colliery, and Mr. Richard Smith, Little Green, Collyhurst, were elected members of the Society.

The Chairman—There is a question as to whether we should have any more excursions as soon as the spring commences. We had an excursion last autumn, and now is the time, if any gentleman wishes to propose an excursion, to suggest some interesting places to visit.

After a pause, the Chairman said—As no one appears to have any proposal to make at present, I will read the paper for Mr. Bland, who is unable to be present, if Mr. Knowles will take the chair.

Mr. Andrew Knowles, one of the Vice-Presidents, then took the chair, and Mr. Binney read the following paper, which had been communicated to the Society through him, by J. S. Bland, Esq.:—

On THE CARBONIFEROUS ROCKS in the neighbourhood of SHAP and CROSBY RAVENSWORTH:—a section of that series which lies on the northern and eastern extremities of the Lake district.

(See Lithographed Section.)

The rocks under immediate consideration in the present paper, are a series of the Lower Carboniferous, or Mountain Limestone, located on the east side of the Lake Mountains in Westmoreland. These, it is well known, flank the old slate rocks of which the mountains are formed, on nearly all sides; but most regularly in the north-west, north, and north-east; running from Egremont by Brigham, Ireby, Greystoke, Lowther, Shap, Orton, to Ravenstonedale. It is a portion, or section of this series, which the map represents, in the vicinity of Shap and Crosby Ravensworth, across to the new red sandstone in the neighbourhood of Appleby. The new red sandstone, in its turn, overlies the carboniferous series, covering the whole of the north of Cumberland,

from Maryport, around by Penrith, Ormside, to Kirkby Stephen, which is the extreme southern point it reaches. From there the line runs back by Brough, and the side of the Crossfell range, to Brampton, in Cumberland, and so northwards into Scotland.

My observations are chiefly confined to the limits indicated by the map, where the series are about eight miles across; in this portion they are most fully developed; that is, all the different strata, which have been formed during that era, are represented; which is not the case in any other part of the series throughout, Before enumerating its different formations, a sketch of the older rocks, upon which they are founded, may, in some measure, elucidate the position in which they are now found.

About a mile from Shap Wells, on the west side of the road, leading from Kendal to Shap, are Wasdale Crags, the crest of a great mountain mass of porphyritic granite, compounded of crystals of felspar, quartz, and black mica; the felspar predominating in large red-coloured crystals: flanking this granite, on the north, and north-east sides, are the lower Silurian, or green slate rocks, in a more or less metamorphic state; on the south, and south-east sides, are the Coniston series of flags, also considered as the lower Silurian, but of later formation; lying between these, is the Coniston limestone, described by Professor Sedgwick as running in an almost direct line from Amblesido, right against the Wasdale granite, where it is lost sight of; there is, however, a small portion of a metamorphic character, out of which springs the Spa, at Shap Wells. This may be identified as a detached fragment, thrown off in the general commotion, when Wasdale Crags and the Lake mountains in general were raised to their present position. From the granite rocks northwards, across Wet Sleddale, the green slates occur; after which, as far north as Rosgill Moor, are a series of dark shaly slates, similar in character to the Skiddaw slates, and considered by the Lake District geologist, as a detached portion

belonging to that system: from some of these beds, slate pencils are manufactured, fossil specimens of *Graptolites* have been found by Professor Harkness; amongst them also are quantities of nodules, presenting a curious cone-in-cone structure. To the north and west again, are the green slate rocks; these, each in their position, are overlaid, unconformably by the old red sandstone, or where it is wanting, by the carboniferous series. These rocks, therefore, formed the dry land, against which the waves of the old red sandstone sea made their last throw,—a wild and barren coast; and though thousands of years have elapsed since that time, Shap Fells are still worthy of a similar title. The old red sandstone, lying upon each of the different series enumerated, represents a coast-line, nearly at right angles to that of the Coniston group of deposits; consequently, a great change in the relative position of land and water must have taken place about the close of the Silurian era; of which, Shap granite has in this district been the disturbing power. The old red sandstone deposit at Shap Wells, and southward as far as Tebay, is a considerable thickness of dark red sandstones, in its lower strata, with conglomerates above. From Shap Wells, northwards as far as Shap Abbey, its position is merely indicated by a stratum of conglomerate and red shales, evidently the shingly and heterogeneous deposits of an ancient shore; the best sections of it, and the manner of its deposit, may be seen at the railway cutting at Shap Summit. This cut, famous in the annals of railway engineering, as being a tough and expensive job, is right through a hill of hard metamorphic green slate rock, which, when the old red sandstone waters washed this coast, was a small peninsula or promontory of rock running out into the sea, presenting steep cliffs at low water, but nearly submerged by the higher tides. On each side of the hill, not quite to its summit, are the deposits of the old shore; first, at the bottom of the cliff, a true sandstone of only small thickness; after it, red shales and coarse conglomerates; higher still, the red colour disappears, and beds of fine gravel have

been formed of the disintegrated slate and granite rocks from the neighbouring hills. This has been washed, and tossed about by fierce storms, into the crevices and hollows of the sea cliffs, where it may now be seen, as regularly stratified as any other shingle on the coasts of the present day. A similar section may be seen at Shap Abbey and Rosgill, where, amongst its lower deposits, are some curious concretionary nodules. This coast line is not traceable any further north; but at the foot of Ullswater, the old red is found of considerable thickness. It is difficult to tell whether the upper beds of this old shore line belong to the old red sandstone, or the carboniferous series; we may safely, however, admit it as marking the transition, and faithfully recording the fact, that at that time no commotion had disturbed the relative positions of land and water on this coast, such as marked the close of the Silurian era; for upon it rest conformably the lowest of the carboniferous series.

The first deposit in ascending order, after the ancient shore, is a limestone of considerable thickness; it is of three different characters, the lowest strata are of dun colour, the calcareous matter of which is held in a loose state of crystallization, and mixed considerably with fine mud; its stratification is somewhat irregular, and it contains numbers of vesicles, varying in size from a marble to a man's head, encrusted, or completely filled, with beautiful rhomboidal crystals of spar—carbonate of lime. The next higher division is much more compact, hard, and more regularly stratified; it is also more highly crystallized, and contains a large proportion of silica in its composition; the upper part partakes more of the character of a calcareous conglomerate, being made up of limestone, or sandy matrix, containing quantities of waterworn white quartz pebbles, from the size of a pigeon's egg downwards; very few of the pebbles are of the blue slate rock, with which white quartz veins are associated on the fells; the absence of these may be accounted for, from the fact, that being of a softer nature, they have been reduced to mud by the rolling action of the water, while

the hard quartz has considerably resisted it; these are not strictly confined to the uppermost beds of the limestone, but may be found in the earliest deposits of the muddy limestone at Shap Summit. The thickest beds containing them are at Shap; these become thinner, and contain fewer pebbles each way, till within a short distance no more are found. In the lowest division, the chief fossils are portions of *Stigmaria* and *Lepidodendron;* the latter sometimes tapering, and two or three feet long. The most numerous of its flora are *Calamites* and *Equisetaceæ*, which, on being first disentombed, are black with carbonaceous matter, some crushed flat, while many are perfect casts of carbonate of lime, with the black matter coating them. These, in some places, cause a cleavage in the stone, from a quantity having been confusedly thrown together, and settled; very few shells are found, and but one species of coral, in the middle division, which is very rare in any of the succeeding strata; specimens of this may sometimes be found in the conglomerate beds, up side down, and pebbles fixed into the crevices of the coral. From the general character of this limestone, it must have been a littoral deposit; at least the outcrop of the lower and upper divisions, from its impure character, and being interstratified with thin beds of clay, or sand, and conglomerate: it has been deposited in a quiet sea, subject, however, to various changes in tidal currents; the vegetable remains floated from the land, when soaked, have settled quietly in the calcareous mud, and in undergoing decomposition, have given out gases, which, on rising in globules through a semi-viscous mud at the bottom of a quiet sea, have become stationary and so fixed. This limestone makes very good mortar, from containing a large proportion of argillaceous matter, requiring little or no sand in admixture. This formation generally presents steep rising ground, with the old shore line at the bottom. The next in ascending order is a thick sandstone, the outcrop of which is the second steep hill; it is the most important in quality, affording thick blocks of a fine grain, and delicate cream colour, well adapted,

from the hardness it attains on exposure, for architectural purposes. The new arch and pulpit at Crosby Ravensworth church are of this stone, and also all the architectural work in the ruins of Shap Abbey. Some beds contain large nodules, from a few pounds to a ton in weight, spherical, of a bluish-brown colour, and extremely hard; beautiful examples of molecular re-arrangement. This sandstone, like all others in the series, is variable, in one place being very fine, and at another quite coarse; its fossil remains are large beds of *Calamites*, &c., deposited similarly to those in the limestone below, but they have been subject to more pressure; there are also ripple marks, characteristic of nearly all sandstones. These, with the fossils, are in the lower beds; the higher ones seem to have been a deeper-sea deposit. Rising the hill still further, above the sandstone is an escarpment of limestone. This is of a blue colour, and of very fine texture; it contains large numbers of flint nodules; the flint in some cases predominates so much as to form beds, interstratified with the limestone. These beds are very prolific in fossils, especially *Goniatites*, which are the characteristic fossils of the rock; some are most beautifully preserved in the flint strata formed of silica, almost pure white. Associated with them are innumerable quantities of *Productæ*, on the upper surface of each stratum, lying in beds like the modern cockle or mussel, at the bottom of the sea, when some flow of sedimentary matter has settled down and entombed them, to be succeeded by other generations, in their turn, to share a similar fate. During the gradual deposit of stratum after stratum, corals of several beautiful varieties have fixed themselves to the hardened mud, or some dead shell at the bottom of the sea, and diligently erected their little temples; but they have never attained a size of more than five or six inches in height. This must either be the natural size, or, the calcareous matter gradually settling down, buried them, so that further construction was left off, and others began again and again on the surface, again and again to be buried; some of these being much harder than the stone in

which they are fixed, weather out beautifully on exposure, especially the *Cyathophyllum*, the *Astræa*, and a species of brain coral. The *Flora*, like that of the preceding strata, is chiefly of the *Calamite* family, but only small fragments, beautifully preserved in the body of the limestone, and in many places so numerous, that, split the solid stone however often, it affords specimens of the delicate stems of the *Sigillaria*, *Lepidodendron*, and beautifully jointed reed like plants; all of which must have been floated no great distance from the land, and settled along with the calcareous deposit.

A slight change has now taken place in the diversity of other lands, or the sea bottom, affecting the currents; the land has gradually risen, and we next find a deposit of a sandy composition, only a very few feet in thickness, upon which follow the innumerable beds of limestone, forming the Great Orton Scar strata, of immense thickness. Its lower series partake of the character of a deep-sea deposit; but what power, and how directed, has raised them to their present high elevation, without considerably disturbing the under-lying strata, is difficult to define. It forms the whole of Asby and Orton Scars, Hardendale Nab, and Knipe Scar, the highest peaks in the surrounding country, vying with in height and precipitous escarpments the old slate mountains. It may truly be termed the backbone of the era, for the country falls both ways, whether we climb up the strata, geologically speaking, to the new red sandstone, or down to the old red. Its general colour is white, slightly tinged with red; its crystalline texture is variable, as also its durability, some portions yielding more freely to the action of acids and water than others; and hence it may always be known by having a ragged, weatherworn appearance. There are many thousands of acres, known as Orton Scars, of this rock, perfectly bare, a wild barren stony wilderness, seldom relieved of its monotonous gray tone, save by here and there the fronds of the bracken, or more delicately-shaped fern, in the crevices. It is not a plain of smooth stone, but broken up, and traversed in all directions by

chasms ten or twenty feet deep, and from six to ten feet across. These are largest parallel to the strike, and are crossed at right angles by others, cutting it up into immense square blocks, in their turn broken by smaller fissures, into smaller blocks; the surface stone is called the clint, or clint cap, which, from its diversity, affords a good study of the way molecular attraction, or adhesion, has acted when the material forming the stone was in a viscid state; where it has been deposited in thin layers it is broken into small pieces, each having a peculiar metallic sound when struck, so that in walking over it, each step awakens the ear to an inharmonious jingle of stony music; again, where the molecular attraction has governed a great extent, and the beds are thicker, the stones are large and rounded into shapes, which the imaginative may picture into grand or grotesque objects; others are irregularly drilled through and through, like a sponge, as the composition is softer or harder; others, again, are of an uniform hard texture, and for acres together present a smooth, polished surface. These, after a shower, reflect the sun's rays so brilliantly that they are called "The Shining Stones." From its great extent and barren character, it affords good opportunities of observing the forces that have been at work in forming our limestones; the large fissures breaking it into square irregular blocks, —evidences of the shrinkage in passing from a viscid to a stony structure, cracking and re-cracking as the hardening went on, the clint cap, which is generally the hardest part of the rock, baking and hardening as molecular attraction directed, finally to be the sport of storms in succeeding eras,—wildly carving fantastic forms. From being of such great thickness, the shrinkage cracks extend deep into the strata in all directions, affording various crevices for the percolation of water; which, in its turn, washing in acids, wearing, and dissolving, continually widens these, and in lateral directions breaks open new ones, which, through length of time, become extensive caverns. The only one at present known in these rocks is the Pate Hole at Asby; it is formed by a hard bed being

superimposed upon a softer one; the latter has been worn away into a channel, about eight feet wide, by from three to twelve feet high; it has been explored upwards of half a mile, but beyond that deep water forms a barrier. No cavernous remains have been found in it, and probably, from being subject to sudden and frequent outpourings of water, it may never have been the resort of animals. It is no doubt supplied by the water sinking into the crevices on the high grounds; this sinking is also the cause of what are called Pot Holes, occurring on all limestone lands, the water causing in its downward course a sinking of the earth into circular cavities. There is another set of fissures on Asby Scar, containing copper ore; these veins may be traced in some places along the surface. They were at one time worked, but either from want of enterprise, or sufficient returns, were abandoned. A marble mill was also set to work, but with like success; some of the stone when cut and polished presents a beautiful mottled surface of a slightly red colour. In other formations of the same rock, small cracks have, by the percolation of water, often become soldered up by the crystallization of carbonate of lime. On forcing these open again, large specks of lead ore are sometimes found, a fact which, in part, may support the theory of lead being a deposit of crystallization from water. The characteristic fossils are varieties of the *Producta*, which are very numerous, but ill preserved, and often seem distorted or shaken; sometimes the same shell may have made four or five casts, one upon the other, as though it were so many thicknesses of shell; it also contains varieties of coral, *Euomphalus*, *Goniatites* and the black palatal bones of ganoid fish.

Some of the limestones, and all the sandstones, in this series of rocks appear as though the material of which they are formed had settled one stratum above another, without any upheaval of the bottom of the sea, and are of one continued thickness throughout, to the outcrop; while others suggest the idea that the bottom has been gradually pushed up by some upheaving power, or the

current bringing the sedimentary matter forming the stratum, failed to reach the outcrop, the stratum breaking off considerably further back, and the next further still. This is particularly so with the scar limestones, till some change has brought a different material, forming a sediment of sandstone in place of limestone; contrary-wise, sometimes two or three strata of thin limestones and sandstones are found one upon another without falling back.

The sandstone next in order is very thin; and again above it is a limestone of a hard texture, and of a blue colour, in which the crinoids first become numerous; it is a thin limestone, and affords no particular features, excepting that its last surface has afforded a floor, on which have grown immense forests of *Encrinites:* these have flourished and died through many generations, while amongst them have lived numbers of bivalve and univalve shell fish of small size, and a variety of delicately-shaped corals of the *Fenestella* species, also many of the encrinites are coated with the *Berenicea.* These have all been living in great luxuriance, when by some sudden act of nature, a muddy sea has overflown them, breaking and hurling them confusedly together, mixing them amongst its layers as it gradually settled down, and entombing them in its lower beds. It is hard and shaly, but falls on exposure, and almost every lamina disentombs some curious inhabitant of the crinoid forest, from the lowest grade of animal life up to small specimens of the *Orthoceras*; the heads of *Encrinites* are scarce, though stems and branches are numerous. The clay shale is of a dark colour, and at Gaythorn is forty or fifty feet thick; on Bank Moor, tiles and coarse pottery are manufactured from it. This shale is superimposed by a gray purplish sandstone, which may be considered the fourth or fifth in thickness and quality as a building stone; it varies considerably in colour and texture, in a very short distance, being sometimes yellowish, white, deep purple, or flesh-coloured. The mason work in the old parts of Crosby Ravensworth church is of this rock. It contains quantities of *Stigmaria,* while the *Calamite*

family seem to be less numerous. Its uppermost beds on Harbyrn Rigg, immediately below the limestone, are highly reddened with oxide of iron, and beds of shells of the *Pecten*, and other species, lie as though they had been entombed suddenly by the superincumbent limestone. This limestone is very thin, is of a loose ochrey quality, and is almost exclusively made up of broken coral; on two or three points, where it shows itself on high land, there is a stratum of coral, two or three feet thick, clear evidence of an ancient coral reef. The rock partakes very much of the character of a shore, or shallow-water deposit, from the quantities of drifted fragments of shells deposited in beds, some of which are nothing else but the spines of shell fish. The surface, where these deposits are found, shows that fragments of shells, spines, corals, &c., of the lightest character, have been driven forward by the last move of a quiet wave; and the surface clear of these presents a curious drifted curl, as of fine impalpable mud, formed gently by the last ebb in some calm lagoon. The next in order is a thin sandstone, similar in character to the one below, but it is generally overlaid by the next limestone: this is hard, and of a whitish-red colour, presenting no particular features. It is about sixty feet thick, and upon it rests another stratum of sandstone, associated with which are definite traces of another of the old coast lines, particularly interesting in exhibiting the variety of material forming a beach. The stream called Drybeck runs along the old shore line, and cuts through different beds of sand, impure limestone, clay shale, and a red material, formed into nodules. The sandstone contains immense quantities of *Stigmaria*; at one place where a large area is laid bare, these root-like plants run in all directions, interlacing and overlapping each other, six or eight feet long in all directions, forming a perfect network, but in no case affording proof of rising into stems of the *Sigillaria;* they are all slightly flattened, and where the sandy matrix is loose and perishable, they may be picked up in great quantities. It is possible they may have been a running plant on the ground, but more probably below the surface, as the

well known coltsfoot runs in a poor soil at the present day. The calcareous and clayey deposits contain fragments of light shells and spines, of a pearly lustre, with an occasional small *Trilobite;* these have evidently been drifted, and quietly arranged in layers. The next in order is a limestone of deep-sea origin, the bluest in the series, and highly crystallized. Some portions are curiously granulated, having scattered through their mass small hard globules about the size of a pin's head, which resist the action of the weather more than the rest of the stone. These, in the fracture, are small crystal centres, partaking of the general colour and composition of the stone. It rises in thick large blocks, with scarcely any cleavage or natural cracks: its fossils are not numerous, but well preserved. *Productæ* have attained their largest size; *Crinoids* are numerous, and occasional specimens of the *Nautilus* and *Orthoceras;* also corals, with quantities of fragments, amongst which are enclosed varieties of *Spirifer*, &c. Upon this limestone rests a yellow sandstone of fine texture, and very suitable for architectural work; it is about twelve feet thick, and is the base of a series of shales, sandstones, and thin limestones, interstratified with which are the Reagill coal seams. The most important of these is immediately above the sandstone, with a clay shale floor of two or three feet thick. The upper beds of the sandstone and this shale are full of *Stigmaria*, then follows the coal seam, from six to twelve inches thick. We may consequently infer, that after this sandstone, with its clayey surface, became partially dry land, a rank vegetation of *Sigillaria* flourished, running their stigmarian roots deep into the clay and sand, till a sinking of the land brought the sea once more over it, and another deposit of clay shale six feet thick covered up the vegetable matter, gradually to be compressed and mineralized. Very few specimens of any other vegetable remains are found in its associated deposits, with the exception of a few of the *Calamite* species. Next above the clay shale is a hard limestone about two feet thick, called the Ironstone. It is of a deep blue colour, but oxidizes red; it has a metallic sound when

struck; then follows another shale, in the lower part of which is a stratum of red irony clay nodules, some assuming the cone-in-cone structure peculiar to those in the Skiddaw slates. Amongst these are many varieties of shells, and some small *Trilobites*. Shales and sandstones then alternate two or three times, with sometimes a thin seam of coal, one of which is called the Crow Coal, and is two or three inches thick; upon these is another thin limestone of an irregular ferruginous character, affording beautiful variegated corals, *Astræa* and *Cyathophyllum*. It is about nine feet thick, and upon it follows another sandstone, with clay shale, having a seam of coal about eleven inches thick, but not of such extent as the other coal seam. The sandstones are generally of a thin shaly character, ripple-marked, and frequently show various tracks of worms; one, however, is of a block-like ochrey material, and very full of varieties of shells and vegetable remains. The coals, with their associated deposits, are of very small extent; the widest area they afford does not exceed half a mile, and, in the line of the strata, not more than four or five miles, beyond which they either have never been formed, or are overlaid. With respect to the coal formation in these rocks, as a general rule, wherever a clay shale is found lying on a sandstone, it is possible to find in the shale a trace of coal varying from a mere mark to twelve or thirteen inches, according to the length of time the vegetable matter of which it is formed has been allowed to accumulate, or according to the luxuriancy in which it may have grown. There are no fewer than five seams of coal, two of which for a considerable area average ten or twelve inches, while the others can only be found in patches here and there of two or three inches in thickness, and in many places none at all; the carbonaceous matter having been diffused amongst the shales. Another fact worthy of notice is, that the shales resting upon limestone are invariably full of animal, and destitute of vegetable remains, while those upon sandstones are destitute of animal remains. Some of the springs where the water rises off the coal, in the neighbourhood of Reagill, are of a

highly chalybeate character. The coal, lying at no great depth from the surface, it has been the custom to obtain it by sinking shafts, now marked by numbers of mounds, called in the neighbourhood "metal heaps," of the superincumbent shales, &c. In many places, so near was it to the surface, that the shale was bared off, and the coal then taken out. Pit Hills has been worked thus, but at what time was not known, till the late excavations at Shap Abbey gave a clue to the mystery, for on clearing the rubbish from one compartment, a quantity of Reagill coal was found in a heap; so the Old Fathers, so far back, have had a knowledge of the coal in their manor of Reagill. It is not very bituminous, and burns with a dull red, emitting a strong sulphurous smell; it was used considerably up to the last twenty years, but in these railroad days, the Lancashire coal has used it, pretty much as the steam engine has used post horses.

We now take leave of these lesser strata, and cross a series of red coloured limestones, the red colour increasing in intensity upwards; they are also similar in composition, being formed in a great measure of *Encrinitic* fragments. Upon the first of these rests a gray sandstone, followed by another limestone, which is only thin, but very compact and hard. Again follows a sandstone, the thickest in the series; some of its beds are of great thickness, and of very coarse gritty material, often standing out in bold escarpments. Other beds are fine and white, or of a beautiful flesh colour; vegetable remains are very rare in it, and, from its general character it has been of deep-sea origin. This may be also applicable to the limestone overlying it, which is also one of the thickest and most important, and is the last of its race, for upon it rests the new red sandstone. These two may be traced all through this and the sister county; in many places they are almost the only representatives of the lower carboniferous era, having either totally overlaid the others, or they have never been deposited. The Morland limestone, does not, however, immediately follow

the thick sandstone, for between them, in the neighbourhood of Morland and King's Meaburn Scar, there may be found a thin limestone and sandstone. The limestone is of a deep red colour, which, with the red clay shale above it, is perhaps the richest and most prolific in fossil remains of any. It is certainly a shallow water deposit, presenting that peculiar curl on its surface which marks those on Harberwain Rigg. Its upper beds are the site of a very luxuriant forest of crinoids; these are very numerous in the shales, and some may be found with the root attached in their original positions. Associated with them are quantities of the *Fenestella*, beautifully preserved, shells innumerable on every layer, and very frequently remains of small *Trilobites*. Thus, these animals range through the whole of this series, but are only found in deposits of a coast or shallow-water origin, and generally in red clayey material. The sandstone above is decidedly an ancient shore, or sandy beach; it is of a micaceous character, and has been deposited in very minute layers, properly termed "shivery." Large slabs of this have been found indented with rain prints, some of these one-half or one inch in thickness; the under side presents casts exactly corresponding with the cavities on the upper surface. The conclusion therefore is, that the rain forming these marks has not fallen on the top of the first slab, but on the one below, and a fine micaceous mud has so gently settled down as to retain the exact size and shape of the cavity formed by the rain-print, to the height of half an inch or more;—a curious testimony of the weather in time long, long gone by, of a few heavy drops on a mild calm day, when scarcely a ripple disturbed the quiet of that ancient ocean, as it flowed and reflowed over that sandy beach. What the inhabitants of the land were, if any, these rocks have as yet afforded no record; but of the sea, the most gigantic form of animal life has been the *Orthoceras*. These are numerous in the upper red limestones, varying in size from two to four and a half feet in length, perhaps the most gigantic size they have ever attained, and doubtless at that era they were lords of the sea.

The lower beds of the new red sandstone are the next rocks upon the Morland limestone. These, in the southern extremity of the basin, are Breccias, or Brockeram, of great thickness, followed by true sandstone. These, according to Professor Harkness, belong to the Permian; they encroach or recede from the out-crop of the Morland limestone, as the level of the country has permitted, but in no case are they overlying it.

Having given the characteristic features of each rock, in the order of its deposit, it remains now to give an outline of the position they occupy, and of the forces that have been at work. I have said the old red sandstone lies unconformably upon the metamorphic slate rocks: what its angle of dip may be I am not able to say, but probably the same as that of the carboniferous rocks, which, as a general rule, is one in ten, or an angle of 5° rising S.W. and dipping N.E. In some places the angle is greater, as on Hardendale Fell and Nab, while in others they are almost horizontal, showing that agencies have been at work, irregularly heaving and lowering, throughout the long period of their formation. The general rule respecting deposits made by water, is, that stratum after stratum is laid horizontally. There are local exceptions to this, but we may affirm it to have been so with the rocks in question; whence then the inclined angle at which they now lie? There is no certain evidence of any upheaving power having caused it on the west side, but the disturbance is to be found on the east. Crossing over the basin in which is the new red sandstone, we come to another series of carboniferous rocks, similar to those enumerated, in being made up of limestones, sandstones, with coal seams, and clay shales, but with this difference that they form a high mountain range known as the Crossfell Range. If we examine these in the lower series, we find first the Silurian as the lowest or Skiddaw slates traceable, with few exceptions, for many miles. Above it is a conglomerate of quartz, pebbles, and coarse grit, near Knock Pike, which on Roman Fell is the true old red

sandstone; and next in ascending order are the carboniferous rocks, the lowest a limestone of a reddish colour, then a thick shale, followed by a sandstone, to be seen near Howgill Castle; this is again superimposed by a limestone, measuring 120 feet in thickness, and in many respects similar to the before-mentioned Morland limestone. This is traceable up to the middle of Crossfell, and immediately upon it rest the varied strata of millstone grit. To the south, however, along the same range, it is followed by a series of limestones, sandstones, coal, &c., and in one case a layer of basalt twenty-four yards thick, which has been poured over, and again overlaid. These are in the Dufton mining district, where the Morland limestone is the chief lead-bearing stratum. From the top of this range, in the direction of Alston, may be crossed the strike of many different rocks, up to the last of the true coal measures in Durham. After the formation of the last limestone in the valley, we see that the laws of nature have still gone on, raising and lowering the land, while the sea has continued to deposit other series of rocks, one upon another, each in its turn becoming dry land, and so on till the last of the coal formations. Then comes a great convulsion, when a mighty crack has rent the hard surface of the earth from north to south, many miles in length, and now known to geologists as the Crossfell Fault; the effect of which has been to raise the east side into the high mountain range of Crossfell; and to lower the west side, and form the rich basin of the Vale of Eden. So much has been done, between raising one side and lowering the other, that the Silurian and Old Red, which are found at Shap Wells and on Raftland, have been brought to light, the distance between these, from the formations *in situ* at Shap, to the Fault at Crossfell, being about ten miles direct; and the dip being about one in ten, these strata at present would be about a mile deep; so the upheaval on the one hand, and depression on the other, may be the probable cause of the dip we now find.

The volcanic rocks causing this disturbance, may be found, at the

bottom of Knock Pike, as a granite, pushing up a cone of greenstone; also Dufton Pike as a micaceous porphyry; and Murton Pike similarly. At the time of this great disturbance, as the level of the one side was lowered, the new red sandstone sea rushed over the sunken country, from the north, tearing and rushing with a mighty force; breaking up into fragments the old deposited limestone, and mingling with the heterogeneous mass a matrix of red sand, &c., in which way, we may in all probability, account for the immense masses of breccias resting upon the older strata, in the southern extremity of the new red basin. The red sand brought by this flow, has overlaid the intervening valley so much, that, on the Crossfell side you may almost step from the new red to the section of the old. The sea from which were deposited these rocks, eventually withdrew, and our county was then added to that dignified portion of the earth's surface, "The Dry Land;" which it maintained throughout the long ages of the Oolitic, Cretaceous, and Tertiary periods, subject to the wear and tear of storms, and the convulsive throes of earthquakes, till Divine Providence directed the icy sea of the drift era, to cover its naked surface with a coat of gravel, sand, and clay. I may here remark, that the shocks of earthquakes are not unknown even at the present day. So lately as the morning of the 6th of the present month, (December,) the district of which I have been speaking, was visited by a very sensible convulsive quiver.

The map illustrating this paper, represents the rocks previous to their partial covering of Diluvial clay; in which state they may be aptly likened to a limb of some ancient Herculian sculpture, where the artist has thrown aside the shaggy garment, and displayed the bone and sinew, wherein lay a terrible force, and as mighty endurance.

On the motion of Mr. Atkinson, seconded by T. T. Wilkinson, F.R.A.S., a vote of thanks was passed to Mr. Bland, for his valuable paper, and to Mr. Binney for reading it.

Mr. Binney—I became acquainted with Mr. Bland last year, in going over that district to look at some property. He showed me this map, and it occurred to me that I had not seen any map of a limestone district so well worked out by a local man. Mr. Bland has devoted many years to the examination of the becks and gills of his district, and has formed this section. I think the paper a very valuable one, because it shows how the limestone begins to be separated by coal measures. In the limestone of Yorkshire we do not see much separation; but in Scotland, a great part of the coal lies in and under this limestone. Though I agree that the paper is remarkably valuable as regards the order of superposition of the beds of limestone, I do not endorse all the conclusions which the author has arrived at. I do not believe that the beds have been lifted up and down during the formation of the seams of coal as he suggests, but I believe that there have been eras of subsidence and further filling up. I think this will account pretty well for the appearances mentioned, without reversing the order of subsidence so often. We all know the ordinary action of streams, that they bring down an amount of debris which will soon fill up the beds of tolerably deep seas, and cause them to become shallow. I mention some of these deductions which I do not agree with, especially that about the lifting up of an area, and also the marks which are called rain marks, but with which I think rain has had nothing to do.

Mr. T. T. Wilkinson—I think some of those so-called rain marks are rather due to the bursting from the strata of bubbles of carbonic acid, or some other gas from below. I have noticed on the banks of stagnant water, for instance, that small portions of gas have forced their way through the soft mud, and have left marks on the mud similar to those which are now generally termed rain marks. If a deposit were formed over these gas holes, as I may term them, on the separation of the layers at this place, just the same appearance

would be presented as that which has obtained the name of "rain markings," or "rain drops," on the sandstone and the shale generally.

Mr. Binney—Their being caused by rain is merely a supposition.

Mr. Joseph Dickinson, President of the society—Mr. Wilkinson has noticed the same point respecting these so-called rain marks, that I noticed many years ago in the roof of coal seams. I believe that they are neither more nor less than the marks left in a soft deposit by bursts of gas. I do not believe they are all so, but I do think that most of those you find in the coal measures are so formed. The part of the country represented on the map sent by Mr. Bland is one that I have not before seen laid down with such detail as we have here; and commencing as it does at a point where the limestone begins to be broken up, makes it of unusual interest. Beginning at Crossfell, (where he tells you there are coal beds found in this lower region,) and continuing to Alston Moor, and the banks of the Tyne, northward along the entire northern range, I am very familiar with the whole of that part of the country. My grandfather was mineral agent there for the Commissioners of Greenwich Hospital, to whom the manor belongs, and I may say I know almost every stratum in that neighbourhood. Mr. Westgarth Foster, in his sections and book published forty years ago, laid down and named every stratum, and following upon that, I assisted Mr. Sopwith in making a longitudinal section from Hownes Gill to the summit of Crossfell, a distance of about thirty miles; and also in making sections of the strata on the extensive manor belonging to Sir Edward Blackett; so that I know the district perhaps better than many here present. I am sorry to see no scale attached to it.

Mr. Binney—It is about ten miles across.

Mr. Dickinson—I thought to gather from the scale the thickness of the limestone on the section.

Mr. Binney—He does not give it.

Mr. Dickinson—I think you will find from the highest limestone, close on the summit of Crossfell mountain, there is a vertical thickness of between 700 and 750 yards of strata, which contain beds of limestone; and then below that portion you get into the strata in which no more limestone is found. In close contiguity with the upper limestone, there is an appearance of coal; and then as you get lower down, nearer the middle of the limestone, you get further appearances of coal. But at Crossfell none of this coal is very valuable. The people scarcely make any use of it, but sometimes mix it with peat and clay, when it makes a very poor fire indeed. But when you go a little further towards where the north and the south Tyne unite, near Hexham, at a place called Fourstones, one of these coals has become good, and four feet thick, and is now in active operation of being worked by Mr. Benson. The roof of that coal is a bed of limestone several yards in thickness. As you proceed northwards these beds are of a more important character, and become associated with the best seams. As there is no scale attached to the section accompanying the paper, it is difficult to connect the coals and limestone beds shown in it with those further northwards, but I think from the glance I am able to take of it, that the strata are not so much divided as they are further northwards, where the beds of limestone become more numerous and more divided.

Mr. Atkinson—I should like to know whether Mr. Bland intends to give that map to our Society.

Mr. Binney—I am pretty certain he does not. His reason for not giving the thicknesses of the strata, is that the section is on the

same scale as the map is. In going over eight or ten miles of country, he has not been so bold or presumptuous as to put down every foot of thickness.

Mr. Dickinson—There is a bed of basalt which continues through all the northern region. The bottom of the basalt is plainly to be seen at a place near Middleton in Teesdale, called Tees Force, where it overlies limestone strata; and on the north side of the Tyne, the site of the old Roman wall runs on the top of this basalt, with limestone overlying.

Mr. Atkinson—Is it a basaltic dyke, similar to those which occur in the coal-fields to the north-east of the district shown on the map?

Mr. Dickinson—No, it is regularly stratified.

Mr. Binney—Just like the Toadstone in Derbyshire, which extends over a great area. There is no trace of any dykes in the district represented in this map.

Mr. Dickinson—The dykes alluded to by Mr. Atkinson run through Northumberland and Durham.

Mr. Binney—Yes; but not through this district: there are plenty in other districts, but none here. The basalt here occurs as a stratified deposit.

Mr. Wilkinson—I think it a pity the map cannot be reduced and published.

Mr. Binney—It would be very desirable if we had funds like the Mining Engineers of the North of England. We find if we were always to publish these large maps and sections, we should be in

"queer street" at the end of the year. We consider that the publication of the section will be as much as we can manage.

Mr. Dickinson—I would have wished for the map to be published as well. I do not think we could hand over our funds to a better purpose.

Mr. Atkinson—If the map were reduced to one fourth the size it would not be a large one.

Mr. Dickinson—Or one eighth of the size.

Mr. Atkinson—But I think it would be difficult to represent some portions on so small a scale.

The Chairman—I suppose the map will be published by the Geological Survey?

Mr. Dickinson—We may be all dead before the Geological Survey gets up there, (laughter). Still I think a record of this sort would be a good guide to them.

Mr. Peter Spence—I believe this is the first time I have heard that copper was worked in that district.

Mr. Dickinson—There has not been found in that district any large amount of copper. It is chiefly lead that it contains. The quantity of lead that is raised in other parts, bears I believe, a small proportion to the quantity produced from the mountain limestone.

Mr. Spence—Alston Moor, in Cumberland, produces more lead than any other locality.

Mr. Dickinson—It is generally in the limestone strata that the great bulk of the lead ore is found deposited in the vein. Sometimes sandstone contains a little, but the shale seldom does.

Mr. Spence—Zinc is largely found there, accompanying the lead.

Mr. Dickinson—Yes; but zinc has seldom been found yet sufficiently valuable to be mined for exclusively. There are old lead-mine workings being worked over for zinc. Some years ago a zinc company was started there; but it involved a very large loss upon the proprietors. In the lead mines the zinc now is separated from the lead ore and smelted.

Mr. Wilkinson—We have a lead mine running from north-west to south-east, through a large extent of country; and strange to say, the direction of the fracture of the coal is in the magnetic meridian.

Mr. Dickinson—I do not think the cracking of the rocks arises from the cause mentioned in the paper; but taking the general features of this paper, I think it a very good and a very valuable one.

Mr. Binney—I think the barrenness of the rocks, in regard to minerals, rather remarkable. You see it prevailing in Cumberland, and when you get to Crossfell all the metalliferous deposits come in.

Mr. Spence—Crossfell contains large deposits of copper ore.

Mr. Dickinson—There is a lead mine on Crossfell.

Mr. Spence—I have been in one there.

Mr. Binney—Near Melberby there have been one or two mining trials, and the results rather damped the energies of those who undertook them. Some of the limestones in the district under notice exhibit a very polished appearance. I have observed on the top of some of the scars, that the limestone is polished like marble. I have also noticed in the neighbourhood of Burnley, in Shedden Clough, that the limestone in the gravel there is rounded, and has the polish of marble.

This concluded the proceedings.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 4.] Vol. IV. Session 1862-63.

The monthly meeting was held in the Museum, Peter Street, on Tuesday, January 27th.

Joseph Dickinson, F.G.S., the President, in the Chair.

The President said his first duty was to announce the election by the Council of three new ordinary members, viz: Mr. F. R. Fairbank, Hulme; Mr. Thomas Pilkington, Bury; and Mr. James Fraser, also of Bury. The next thing he had to do was to draw the attention of the meeting to two beautiful specimens of *Aviculopecten* from the "Upper Foot Mine," Oldham, presented by Mr. Butterworth, of Moor Side. The chief merit of these specimens was that they retained their natural convex form; specimens of this fossil being generally found quite flat.

Mr. E. W. Binney said these were certainly very beautiful specimens of the *Aviculopecten papyraceus*. They are from the large nodules lying over the Upper Foot Coal at Doghill, near Oldham; the first mine above the Gannister.

A coversation then took place respecting the marine shells found

in the black shales, on the banks of the river Tame, at Dukinfield. Mr. Taylor said he had there found a *Goniatites Listeri* as large as the palm of his hand, and also a crinoidal stem. Mr. Binney had found *Orthoceratites* at the same place. These beds were generally looked upon as some of the lower series of coal-measures brought up by a fault, but no one has gone through the strata there, and no fault having been proved, they may not unfairly be considered to belong to the upper coal-field. The President said, if these shells be a discovery of *Aviculopectens* in the higher series of coal-measures, we must accept the discovery. Mr. G. Charlton said there was a sufficient breadth of strata between those known on each side to admit of the existence of a fault, but there were no indications of one that could throw up the lower measures there.

The following paper was then read:—

THE

CAMBRIAN STRATA OF THE ISLE OF MAN;

BY JOHN TAYLOR, ESQ.

The following notes are the results of observations made on the Manx Cambrians during a series of visits, but more especially in the autumn of last year. Many of the facts have already appeared, worked out and developed by one or two diligent labourers, more especially by the Rev. Mr. Cumming, F.G.S., who lived in the Island for several years. The remainder, which I lay before the Society as worthy, at least, of remark, are the results of my own investigation. The Island has not been geologically surveyed, except by amateurs, nevertheless it is pretty well understood, and I think that the study of the slate formation here may throw some light upon beds of synchronic age elsewhere.

The sum of Manx geology may be stated in a few words. Along the southern coast, on each side of Castletown, and having that place as a centre, the carboniferous limestone skirts the coast. It is separated into two divisions by a thick bed of dark and thinly laminated shales, many of which are cored with *Producta*, &c. From underneath the lower beds of limestone, what Mr. Cumming calls the conglomerate of the old red sandstone, crops out. This bed, however, I take to be a sort of passage from the carboniferous downwards, rather than a representative of the Devonian formation. Certainly the Palæontological evidence is not in favour of its being decidedly old red, for the fossils most abundant are *Orthis Sharpei*, and *Favosites polymorpha;* both these extinct forms being common to the Upper Silurian, as well as the Devonian, and the latter is common both to them and the carboniferous limestone. Striking off from the coast inland, we find that these two deposits terminate in about two miles; and, in going up the Silverburn, we see them cropping out; first the limestone and afterwards the red sandstone, both abutting against the highly inclined strata of the Cambrian beds. The area which the limestone and red sandstone occupy is of a crescent form, having Poolrash on its right horn and Santon-burn on its left—the whole distance being much disturbed by outbursts of greenstone, and trappean dykes.

From Port le Maury, along the north-western coast, we come upon the slate rocks, until we arrive at Peel, where a dun-coloured red sandstone rests upon them; the red sandstone rocks lying at a low angle. These beds skirt the coast as far as the Point of Ayr, but do not extend into the interior for a greater distance than four miles. The farthest inland point to which they extend being Kirkpartrick, where they are seen resting on the still highly inclined Cambrian strata. With the exception of these Palæozoic deposits, and the more recently accumulated beds of Pleistocene age, the whole of the Island is occupied by the Cambrian formation.

In the editorial note attached to an article of mine published

in the "Geologist" magazine of September last, Mr. Salter observes, that we cannot tell whether these Manx clay slates belong to the Cambrian formation or not, until they have been properly surveyed. At the most this *dictum* is not attaching much value to the researches of Stickland, Forbes, or Cumming; and anyone acquainted with but the slightest knowledge of the Welsh Cambrians, on arriving at the Island would not fail to recognise in its highly contorted beds the representative of the former. I have no doubt whatever but that these Manx beds belong to the true Cambrian system. So nearly are they allied in mineral structure to those of Wales, that practical slate dealers are unable to tell the difference between the slates obtained from the recently opened quarries of the Island, and those obtained at Conway. And not only in the mineralogical appearance of the beds is there a similarity, but also in the organic remains, few though they be, which the Manx beds have yielded. At the same time we have seen that the supposed representative of the old red sandstone, as well as the overlying carboniferous limestone, both abut, and rest on the clay slates themselves.

Owing to the contortions into which the clay slates are thrown, it is exceedingly difficult to ascertain their thickness. It cannot be less, however, than several thousand feet. The general strike of the beds is E. N. E., the strata running in parallel mountain ridges, of which the principal one is that passing through Slieanwhallin and North Barrule. The valleys between these principal ridges are mostly formed by the synclinal depressions of the strata—from one end to the other—the whole tract of the Cambrians being highly contorted, and broken up by faults. So powerfully have these contorting forces operated that I have seen, within the distance of twenty yards, no fewer than a dozen foldings. A good section, showing this phenomenon, may be seen along the vertical coast line around Douglas Head, for a distance of three miles. Again, on the opposite side of Douglas Bay, the same feature presents itself, and a little farther in the easterly direction, at Onchan, the rocks

bounding its little bay are seen to form a huge anticlinal ridge, the strata passing over like the roof of an arch. All along this coast as far as Ramsey, the same phenomenon may be studied, and the huge rocks contorted in their strike like the massy folds of snakes, changing in their colour, and worn out at their base, with the constant attacks of the sea, into fantastic curves, when seen by the light of the setting sun, form a scene impressive enough to strike the imgination of the beholder with awe and delight. At times, however, we find that great faults have intervened, arresting the agency which has so folded the strata, and turning it into another direction. Thus, on the eastern side of Greeba Mountain, the strata are exceedingly disturbed; great veins of white quartz intersecting the beds, and completely breaking them up. On walking along the ridge of the mountain, and along the strike of the rocks, we perceive this folding suddenly to cease, and then the beds lie at a steep angle, but quite free from contortion. This peculiarity has been taken advantage of by Messrs. Ashe, and splendid slabs, fit for street pavements, etc., are now obtained from a quarry which they have recently opened there. Again, on a mountain opposite to Greeba, and to the east of it, the Craig, we find the beds dipping at an angle of about 45°, but these are finely laminated blue slates, quite sonorous and hard, and fit for building purposes. The masses are also naturally cloven into rhombic forms. Further towards Peel, there is a slate quarry recently opened by the Isle of Man Slate Company, where the strata lie at a lower angle still, for the dip here is only about 30°; the rhombic cleavage still prevailing. But by far the finest section is that at Dalby, and seen from the coast. A fault occurs here, and, on the one hand the beds are in nearly a vertical position, whilst on the others, are seen abutting against them, in a similar manner to that in which, when books have been taken from a shelf, the inclined ones will lie against the vertical.

The colour of these beds is not persistent. Near Douglas they have a sort of olive grey; at Santon-burn they are of a claret

colour; and in the slate quarries to which I have alluded, they are perfectly blue. Like many of the Welsh slates, the surfaces of the laminæ are often coated with pyrites; and between the chinks of the cleavage the faces of the masses are nearly always so coated. The difference in hardness is also variable, in some places they are almost as soft as common coal-shales, whilst in others I have seen beds sufficiently hard and crystalline to take a considerable polish.

The organic remains are very scarce, and until a few years ago, were thought to be quite absent. A friend of mine, Mr. Grindley, has, however, discovered a *fucoid;* and in the quarries behind Castle Mona Hotel I have discovered both *fucoids* and the *tracks or castings of worms*. Again, in the slate quarry of Messrs. Ashe, at Mount Craig, I have found, what I esteem the section of an *Orthoceratite*,—the specimen showing the chambers, and also the gradual tapering of the body of the shell. The outline, as well as the transverse divisions of the septa, are composed of carbonate of lime. Near Laxey, ripple-marked slabs are exceedingly abundant; and, at the new jetty the top is paved with such slabs, whose surfaces are marked so distinctly with ripples, that we can see at once, from the illustration of the sands below, marked by the tides of the morning, that the same agency originated both phenomena.

At Dalby, and very near the spot where the above-mentioned fault occurs, a quarry has been recently opened in the vertical strata, and the ripple-marks on the rocks *in situ*, are mostly plainly to be seen. But by far the most important discovery is one which I had the good fortune to stumble upon last summer. Judging from the shallow-water evidences which the ripple-marked slabs presented, that this was a favourable place to look carefully for organic remains, I devoted part of the afternoon to the task. Judge then of my surprise to find that one of the vertical faces of the rock was distinctly marked by impressions, each about nine inches long, and following each other at a distance of about two feet The impressions were about four inches on each side of a straight line,

and were alternately on this side and on that. Three such impressions were distinctly visible, and doubtless on the same face of the slab more would have been met with, but masses of over-lying rock intercepted the view. I got the slab quarried, and, but for its being in London, I should have been glad to have exhibited it. The accompanying drawing, however, is a tolerable representation of the appearance of these imprints.* These impressions were described by me in the above-mentioned article in the "Geologist." In opposition to Mr. Salter, who had not then seen the slabs, but only the drawing, and who was of the opinion that they were not organic, Mr. Mackie stated that he had no doubt of their organic origin, but was of the opinion that they belonged to a gigantic species of *Lingula*. Whatever they are, I cannot tell, I have simply brought them before the notice of science, conscious that all traces of fossils which are found in the Cambrian beds will receive a careful examination. Whether they be *actual* footprints of some Chelonian, or merely imprints, I cannot say; but impressions of Chelonians have been found in the lowest Silurians of North America, and more recently, I believe, in Scotland. The outline of these Dalby impressions very much resembles the dotted outline of of the *Protichnites*, figured in Owen's "Palseontology."

Thin veins of *Anthracite* have been met with at Laxey, and near to Ballacraine, a lode of impure *Graphite*, or *Plumbago*, crosses the valley. If, therefore, the latter mineral be found to be of organic origin, at the time that these Cambrian beds were formed, some not far distant land had a share of vegetation; or at least to the sea-weeds of the Cambrian oceans must these *Anthracite* and *Graphite* beds be due; while the scanty remains of former life—scanty, for in all the thousands of feet of these rocks, their discovery is the *exception*, instead of the *rule*—show that both sea and land had their limited fauna and flora.

* We hope to be able to examine the Slabs soon, and to give a drawing of some of the markings upon them.—*Ed.*

Granite comes up to the surface in two distinct places on the Island, and in both instances emerges from beneath the slate rocks. The first place is at South Barool, and the second at Dhoon, about two miles beyond Laxey. In both instances it comes up as a huge bulging mass, or boss; in the former place occupying many square acres in extent. Around this boss there is a belt of pure white quartz, some score or two of yards wide, and containing large flakes of mica interspersed among it. At the junction of the clay-slate with the quartz the mica is more abundant, and for a short distance a sort of mica-shist passes into the slate-rocks. In the Cambrian strata of the Island several layers of rock are fine-grained sandstone, as at the eastern horn of Douglas Bay, and again at the "Quarter Bridge," about two miles from Douglas. And it would seem that this belt of white quartz has been formed out of such sandstone beds by the heat which attended the gigantic outburst metamorphosing them. At the Dhoon, the junction of the granite and the slate rocks is also accompanied with evidence of heat, for the slates, quite blue a few yards away, close to the granite are baked almost into porcellanite, and are almost as white as the baked heated shales which sometimes fall among the ashes of our kitchen fires. It is in the neighbourhoods of the granite that the metallic veins and lodes are richest, for at one place the Foxdale mines are most profitably worked, and near to the other we have the extensive works of the Laxey Mining Company.

The Cambrian strata in the Island bear evidence of extensive denudation, for most of the valleys have been formed by the literal scooping out of rock; and it is not unfrequently the case that the hills on each side of such valleys may be seen to be the abutments of great arches of strata which have once bridged over. If the experiments of Sir James Hall have any merit, and I think they are explanatory of the lower seated rocks in the various contortions which they present—huge masses of overlying strata must have been denuded off the present Cambrian beds. The experiments of that gentleman showed, that wherever we meet with these violently

twisted and convoluted beds, at the time when the phenomenon took place, hundreds, if not thousands of feet of solid rock must have overlain them; for under other circumstances the forces which have produced these effects would have developed them under other forms; and, taking in connection with this theory, the statement of Mr. Sorby, that none of the granites of Great Britain could have been formed under a less pressure than 40,000 feet of solid rock—the fact of granitic bosses cropping out to the open daylight, and the phenomenon of the ribbon-like contortions of the Cambrian strata, prove, that there has been, at one time, many thousand feet of solid rock piled above the present beds, the whole of which, along with the upper strata of the slates themselves, have since been removed by denudation, and carried away to form strata of a later age.

There is just a glimpse of what this old land may have been composed of preserved in the red sandstone conglomerate. At Peel, where this conglomerate may be traced resting upon the inclined edges of slates, the imbedded pebbles are many of them of quartz, but *none of slate;* whilst these are accompanied with *limestone pebbles*, in which may be seen fossils of an undoubtedly *Silurian* character. I have many a time chipped out fossil corals and portions of shells from these imbedded pebbles; and, after a shower of rain, when the rocks are clean, they may be observed plentifully strewn among the fragments forming the conglomerate. Some of these limestone pebbles are several inches in length; consequently they could not have been carried from a great distance, and the solid rocks whence they were derived must have lain in the neighbourhood of the conglomerate itself, at the time when it existed as a rough shingle beach. It is therefore probable that the parent rocks of these fossiliferous pebbles once overlaid the present Cambrian strata, and have since been denuded—the conglomerate itself testifying the agency which has caused its removal. Taking the question of this denudation, therefore, as being tolerably certain, the effects upon the commerce of the Island are easy to be seen;

for, had it not been for such an agency, the exceedingly rich lodes of zinc and lead now mined in the slate rocks in the neighbourhood of the granite, would have lain far too deep below for human skill to have reached them, whereas they are now but removed a few fathoms from the light of day.

This question of denudation I purpose to take up in a subsequent paper, in which I shall also dwell upon the agency which has scattered the hundreds of granite boulders broadcast over the plain, at the foot of South Barool.

On the motion of Mr. Binney, seconded by Mr. Hull, the thanks of the meeting were given to Mr. Taylor for his paper.

Mr. Binney—As to the amount of strata that may have been removed, there is plenty of scope for denudation; there is no difficulty about that. The question is whether these rocks are not rather Lower Silurian than Cambrian; and that is a point not very easily decided. In regard to the markings, mentioned in the paper, I should not like to give an opinion, whether they are tracks or not, from seeing only a drawing of them; I should like to see the slabs themselves. There has been a reference made to Mr. Salter, and I would just remark that he could find tracks if anybody could find them. May I ask when the slabs will come back from London.

Mr. Taylor—I don't think there will be much difficulty about getting them.

Mr. Binney—I must say it would be very interesting when we see the slabs, if we could find a good track in a Cambrian rock, and I do not see why we should not.

Mr. Taylor—I saw this on the surface of the rock.

The President—Some years ago, when I was looking at some tracks on the limestone, I found some impressions like these. But on more closely examining them they proved to have been produced by the chairs of a tram-road.

Mr. Taylor—In the case of these three impressions I found them on the face of the solid rock.

Mr. Atkinson—I suppose the tracks were on the face of a perpendicular rock; and that the strata have been upheaved into that position.

Mr. Taylor—Yes; they were not on loose blocks, but on the solid face of the rock, standing in a vertical or nearly vertical position.

The President—It is well, I think, to make it distinct that these markings were not taken from loose blocks. In the reading of the paper I did not catch what was meant by the reference to the pressure of 40,000 feet.

Mr. Atkinson—It means the amount of pressure of the superincumbent strata requisite to produce a granular structure. According to the experiments of Sir James Hall, a mass of melted rock cooling under a great pressure would become granular in structure. When Mr. Gregory Watt, too, made experiments on the basaltic rock of Dudley, called Rowley Rag, he found that if the pressure was great, whilst the melted mass was cooling, a substance of a granular texture was produced; if the pressure was less, a more compact or earthly structure was the result; if very little pressure was used, the cooled mass was similar to obsidian or volcanic glass. I am not aware that either of those gentlemen

made any calculations as to the amount of pressure required to produce the crystalline structure of granite—whether 40,000 feet, or any other thickness of overlying strata.

Mr. Taylor—This amount is not taken from any theory of either Sir James Hall or Mr. Gregory Watt. Mr. Sorby, of Sheffield, has made investigations regarding the structure of granite. He has treated the subject at considerable length in his work on crystalline structure. It was to that I referred when I mentioned 40,000 feet as being the minimum depth of strata removed from the granite in question.

The President—It is strange that in descending mines, we find that go as low as we can into any of the measures, either in carboniferous or metalliferous strata, we do not find that the rocks become any more dense, as we get deeper. If any substance is crystallized on the surface of the earth it takes the same form as when it has been crystallized at a great depth where there must have been immense pressure.

Mr. Atkinson—But according to the experiments of Mr. Gregory Watt, when the same substance—the Rowley Rag of Dudley—was melted and allowed to cool under various amounts of pressure, a granular rock, one resembling greenstone, or one of a more earthly texture, or a substance like the common glassy furnace slug was produced, showing plainly that pressure has something to do with the formation of the granular structure of igneous rocks.

Mr. Hull—The granite of the Isle of Man is probably of ancient date. We have strong reason for supposing that it is similar to that of North Wales, on the western coast. If that be the case, there is no reason for supposing that we are to have there the whole series of rocks above the Cambrian or Lower Silurian strata.

There is no reason for supposing that there was even this except for the fragments Mr. Taylor has found in the conglomerate of the red sandstone, which may have been carried to a considerable distance. We all know that well-rounded pebbles may be carried even hundreds of miles. There are pebbles in the Midland Counties, and we have failed altogether to discover their original locality. I think this is a most useful paper, and the observations are very carefully made. As regards these tracks, it appears to me they are quite as likely to be nodules of some kind—a concretionary nodule that may have been dropped out of the rock. But I do not wish to express a positive opinion. It is very hard to judge from drawings in a case of this kind, although the drawings may have been made from the original slab.

Mr. Taylor—I found them at regular intervals and I got a large portion of the slab quarried out. There were no nodules in the rock at this place, and the regularity of the occurrence of the marks, precludes the supposition of their being made by nodules.

The President—Even with nodules it is surprising with what regularity they occur. It seems as though there were not sufficient of the material to form a stratum and it has become formed into nodules with surprising regularity.

Mr. Binney—I do not think we can form a good opinion upon this subject unless we saw the real specimens. The occurrence of ripple-marks in the Silurian and Cambrian rocks is not at all a new fact. There are plenty of them in the Silurian and Cambrian rocks. Mr. Greg presented, some years ago, to this Society, some very good ripple-marks, and some other strange markings from the Cambrian rocks of Wales. But I cannot help thinking we shall have a much better chance of determining accurately what the fossils really are when we see the slabs themselves.

Mr. Readwin—You have mentioned the terms Cambrian and Silurian. May I ask whether you can trace any marked distinction between the so-called Cambrian and Lower Silurian rocks.

Mr. Taylor—No, I cannot say that I distinguished any difference.

Mr. Readwin—Is there anything akin to the Harlech grit in the district?

Mr. Taylor—Oh no.

Mr. Readwin—I have never been there; but I have, in Wales, walked along what is said to be a junction of the Cambrian and Lower Silurian, and observed no distinction.

Mr. Taylor—I think it is a moot point with a great many.

Mr. Readwin—I have examined it for many years and can find no difference; and however the officers of the Geological Survey managed to run that sinuous line along the Dolgelly district, as they did, I have not the slightest idea. At the junction of the Cambrian and Lower Silurian of Merionethshire, I find no marked distinction in the rocks.

Mr. Hull—There is no break there, but there is a break in Ireland.

Mr. Taylor—In Ireland you can only tell by comparison with the ancient Cambrians.

Mr. Readwin—The doubtful character of the ancient Cambrians, as insufficient data to judge from, called forth my remarks. Mr. Taylor might have found gold in the district.

Mr. Binney—Mr. Taylor mentioned that some of the parties who had opened quarries in the Island had said their contents were as good as Welsh slates. Now, I never knew any man who had opened a slate quarry but would go so far as to say this.

Mr. Taylor—I said the character of the Welsh slates and that of those got in the Island, were such that the dealer could not tell which was which.

Mr. Binney—I have been to the Isle of Man, and they told me there that the slates were as good as Penryn slates. If any man has a quarry to sell he always says it is as good as Welsh slate. That is little evidence of their being Cambrian.

The President—If you make use of this statement of Mr. Sorby's, about the 40,000 feet of solid rock, I may mention to you that the variations between the pressure which forms granite and slate must be very trifling, because from the very same specimens I have myself got out of a deep mine, a specimen of granite, and a specimen of slate, both attached; and which I took from the junction of the granite with the slate.

Mr. Atkinson—The slate is an aqueous rock, and must have been deposited upon the granite after its formation, or the granite may have been intruded. There is one thing I may mention in regard to the experiments of Sir James Hall and Mr. Gregory Watt, namely, that *length of time in cooling* was found to be one of the conditions requisite for producing a granitic structure under high pressure.

Mr. Taylor—Mr. Sorby's experiments go to prove that none of the granites have been fused at a greater temperature than 800°

[The President, at this stage of the proceedings, having business

which compelled him to leave the meeting, Mr. Binney took the chair.]

Mr. Binney—Well gentlemen we have travelled a good way out of the Isle of Man, and probably the subject more immediately before us, is connected with that Island. Mr. Sorby I believe has not experimented upon this granite, and therefore I think we ought not to take his name so freely as we have.

Mr. George Charlton—Has Mr. Taylor observed any of the lower coal-measures of the Isle of Man?

Mr. Taylor—There are a series of coal-measures upon the limestone there. Throughout the Island there is great evidence of denudation, and on the tops of some of the hills there are found great boulders of mountain limestone rounded.

Mr. Atkinson—About 20 years ago, when I was in the Isle of Man, they were sinking for coal between Castletown and Peel. I do not, however, know whether anything came of it.

Mr. Taylor—They lost £20,000 by it, that is all. There is no colliery at all at work yet.

Mr. Atkinson—But there are coal-measures.

Mr. Taylor—Yes, there are coal-measures on the limestone. *Anthracite* is found in what I call the Cambrians. It is in thin flakes, and I believe something similar has been found in the series near Whitehaven.

Mr. Hull—It is quite possible that the *Anthracite* in these low rocks may have been derived from marine vegetation.

The Chairman then called upon Mr. Thomas Farrimond to read his paper.

ON THE

EDMOND'S MAIN COLLIERY EXPLOSION;

BY THOMAS FARRIMOND, ESQ.

The appaling catastrophe which occurred at the Edmond's Main Colliery on the 8th of December last, by which 54 persons were hurried into eternity, has created profound sensation throughout the mining districts of this country; but it seems now that the public excitement has gradually died away, although 52 of the persons killed are at this moment entombed in the dark recesses of the Barnsley Nine Feet Mine; a mine wherein, at Lund Hill, in 1857, an explosion occurred, and sacrificed 189 lives; then again the Wombwell Main Colliery has been on fire for the last nine months; the last named and Edmond's Main being partly owned by the same proprietors, and all three works being the same seam, and within a short distance of each other; surely the Barnsley Colliery Proprietors will take warning, and either change this defective system of working, or get the coal exclusively with safety-lamps. I believe that now the time has arrived when the subject matter of this accident can be with propriety submitted to this Society, and the merits or demerits of the manner of working pursued at this colliery calmly and dispassionately considered, with a view of bringing the same to a profitable and practical account, should any of us unfortunately be connected with a colliery placed in a similar position.

The facts which I shall now lay before you are derived solely from the evidence adduced before the Coroner, when the inquiry was held, December 15th, 22nd, and 23rd, touching the cause of the deaths of Davey and Pickering, two of the unfortunate individuals who succeeded, after a life and death struggle, in extricating

themselves from the jaws of that deadly enemy after-damp, resulting from the explosion, which occurred about 11-30 a.m., on the 8th December; but alas, only to meet the same fate as the others who did not succeed in reaching the surface.

The mode of working this mine is the pillar and stall system. As the levels are being driven stalls are entered at right angles, or nearly so, upon the face of the coal, I presume, as they are nearly east and west. First a pair of drifts are started with a pillar of coal about 5 or 10 yards thick; this is followed by a pillar 30 or 40 yards thick, and then a drift, and again follows another thick pillar of about the same dimensions. Openings are cut through these thick pillars about every 20 yards, and then again comes a drift, again a pillar of 5 to 10 yards, and this process is repeated. It will be seen that the pillars are not all the same thickness, as in bord and pillar work. In this Yorkshire system, we have first a pillar 5 or 10 yards thick, then the two next pillars are from 30 to 40 yards thick, and again a pillar 5 or 10 yards, and so on.

The object in having these two thick pillars is to be enabled to rib or widen the drift between them, and so to be working the pillars back while cutting out the places, and find working places for the colliers in a shorter time than if the bord and pillar system was properly worked; for as soon as the drift between these two thick pillars gets about 20 yards up, openings intersect it right and left, the collier working the drift conveying his coal through the opening, and then two ribbing places commence from the level again on each side this drift, and when they get to the opening, turn back to the level and take two more ribbings off in the same manner, and by this time the drift has put through into another opening through which he again takes his coal and makes room for two more ribbing places from his second opening. In this manner it is continued until it reaches the levels above—every opening furnishing two more places. It will be seen for what

object the two drifts are left standing, with the pillar of 5 to 10 yards of coal between them.

After the ribbings have been completed to within a certain distance of the drifts, they are left to be filled full of gases, and become standing goafs, not sufficiently large to let the roof come properly down, as in the wide-work system; but, nevertheless, so much so, as to prevent their being ventilated; and if the mine makes gas at all, they become dangerous reservoirs of this explosive mixture, ready to come out upon the open lights, either by a fall of roof or barometer. This system of working is highly dangerous, and should never be adopted in mines that make the slightest quantity of gas, unless they are worked exclusively with safety-lamps; and even this would not be safe, unless the mine was properly managed; for the firing of shots, which could not be avoided, is always attended with danger where lamps are exclusively used. The only safe mode of working is the bord and pillar system, and I am certain the most economical, as the coal will not be so much crushed. The three pillars left, upon this Yorkshire system, must be expensive to work back, and very much crushed—the two drifts being necessary to air the same during their working.

The Edmond's Main Colliery, as you are aware, consists of two coal-drawing shafts in close proximity to each other, which are used as downcasts, and one upcast shaft distant about 250 yards therefrom; at the bottom of which, were two furnaces, fed exclusively with return air, therefore we may conclude the effect of their rarefying power would be great, when it is given in evidence by John Winter, that 42,120 cubic feet per minute went into the downbrows, and in addition to this there were two other splits, the one making a northern and the other a southern course (of these the quantity of feet has not been given,) from the shafts, consequently when these three splits have passed over two furnaces,

the consumption of fuel must have been great, but the effective motive power would be reduced by the shallowness of the shaft, which was, however, lengthened in some degree by a chimney being erected on its top. The downcast shafts being 105 yards deep, and the upcast shaft about 90 yards. Immediately to the south of the downcast shafts the engine plane commences, being driven double, and bearing N. 85 E., the one being used as the intake and engine-plane, and the furthest from the shaft as the return—this return is carried over the south level intake by means of a crossing, which crossing was blown down by the second explosion, as found by Mr. Madison and his party, and thereby cutting off all communication with the downbrow workings. The air from the downcast pits would take the shortest route, and go direct to the upcast shaft, through this crossing. Was it to be wondered at, that Mr. Madison and his party could not get more than 120 yards downbrow, even had the stoppings not been blown out. The ventilation appears to have gone down the engine-plane, direct to the second half-way, distant from the shaft about 800 yards; and there, there were two splits taken from it, the one going along the second half-way north-west levels, and the other along the second half-way south-east levels. The ventilation here was grievously at fault; there ought to have been two splits taken from it at the first half-way, which is distant from the shaft about 500 yards, of about 9 or 10,000 feet per minute each; which would have been found quite sufficient to sweep the ramifications of benks, brows, and working places of the north-west, and south-east levels of this half-way.

The air having arrived at the second half-way, as before stated, two splits were taken from it, amounting together to about 32,000 feet, the one on the north-west side threading round all the places in this second half-way, and then instead of going direct to the upcast, it had to ventilate the places of the first half-way, north-west side, before going to the upcast shaft. The same course of

procedure was repeated on the south-east side of the engine-plane. The ventilation, after the two splits were taken from it at the second half-way, proceeds down the engine-plane, to Swaithe Level, about 400 yards below the second half-way. The dip bords are entered out of this level, and at right angles thereto, at a short distance from the engine-plane. The air passing along the higher level to the face, and back by the lower; but before getting to the engine-plane it was turned down the straight dip-bord, by means of a single door, placed immediately on the double end pillar, or between this and the backbrow. These dip-bords, which are nothing more than a pair of downbrows, driven upon the extreme dip of the mine, probably with the intention of making them into jigbrows, for the Swaithe pit, the sinking of which was about being completed to this mine, and for which such great anxiety was evinced to effect a junction with it. We are not informed whether the brows were being met from Swaithe pit. The air is conducted to the face of this downbrow, which is called the straight bord-gate, it being in communication with the higher Swaithe Level, by means of a door; if this door was left open, the ventilation of Swaithe Level would be stopped, and the air would have a direct course down the straight bord-gate, without first going through Swaithe Level. Joseph Duckworth deposed that "Henry Lawton shut the straight bord-gate door to Swaithe "Level, which had been forced open by the smoke and hot air— "left Lawton standing by the side of the door, thought Lawton "was studying." No doubt he was considering the consequence which might occur, through this act of his. The closing of this door is quite sufficient to account for the first explosion; the effect of closing it would bring the accumulated gases in Swaithe Level, direct upon the fire, and hence the explosion. It is probable that this door had been left open by the colliers, who had been endeavouring to extinguish the fire in their half suffocated eagerness to escape, and they would naturally have to pass through it. The ventilation after passing down the straight bord-

gate, and round the face, by means of bratticing, returned to the slit, or opening, and then again to the face of the back bord-gate, where the fire took place.

The face being about 9 or 10 yards past the opening, which was 5 feet square, and the quantity of air passing 11,375 feet per minute, a large quantity, by the bye, but such is the fact as given by Winter. After the brattice caught fire in the back-bord, the current of air being in direction of its length, it would soon be consumed, and would probably set fire to the brattice in the intake brow, through the opening; nevertheless it would be against the air; but, if this was effected it would be the means of turning it directly through the opening, without going to the face of the straight bord-gate, and after an opening had been effected, the brattice would burn away tardily, the air being taken off by entering the opening. This place was making a good deal of gas, for two days before the explosion, the blowers caught fire, and it took about an hour to put it out The gas would accumulate in the straight bord, and, probably, in the course of an hour or two, would explode at the brattice, or the fire in the back-bord. The place being 9 or 10 yards past the opening, would be large enough to contain sufficient gas to account for the first explosion. Either from this cause or the opening of the door, I am fully persuaded, it resulted; and not as Mr. Madison said, in the distillation of gas from the coal, brought in contact with a collier's open light. This split has nothing more to do after having ventilated these four places; it then goes to the back engine-plane, passes over the intake, second half-way, south east level, and by means of another crossing, goes over the engine-plane. This last crossing would not have been required if the back engine-brow had kept its original course. The return now reaches the first half-way, crosses the horse road, and is there joined by the north-split; both now go together over the intake or engine-plane. It was in attempting to restore this crossing, that Mr. Madison attributes the second

explosion. After travelling a short distance up the backbrow it receives the south-split, and from this point to the shaft there are only two communications with the dip workings, which were rendered into one by the explosion; and, as in the case of the Hartley catastrophe, this single communication was cut off to the poor fellows, in the working. The return air now reaches the shafts' level, over which it is conducted by means of another crossing, and finally reaches the upcast shaft, where it is rarefied by two furnaces.

We find that J. Shigley, furnace man, "found the smoke coming "to the furnace at half-past Ten, and in fifteen minutes was driven "to the downcast, and went out of the pit, where he saw Geo. "Lawton, who told him he should not have left the top fire; he told "Lawton smoke came to both." It would seem that the top fire was chiefly supplied by the air which ventilated the workings on the rise of the downcast shaft, and consequently would be free from smoke. The total quantity of air passing over these two furnaces, ranged from 82 to 95,000 cubic feet per minute, therefore, we may conclude, that the diameter of the upcast shaft was more than 11 feet, though it has not be given. It will be remembered that the air which ventilated that portion of the workings, where the fire took place, went, after leaving the fire, direct to the upcast shaft, and was only mixed with the other two splits after they had aired the workings at the first and second half-ways; therefore, the furnace man was the only person who would see any smoke, except those who were trying to extinguish the fire; consequently if the explosion had not taken place, the fire might have raged in the dip working for many hours, and the men would have been in safety; in fact the only fear to be apprehended was an explosion, and I do unhesitatingly assert, that if the stoppings and crossings, had been properly made, that is, if the stoppings had been well backed up with rubbish, and the crossings double planked, and secured by holding-down bolts, and backed by rubbish in a sloping

inclination from the centre of the crossing, on the return air sides, the accident would not have been attended with the loss of so many lives. The stoppings and crossings may have been built in a substantial manner, but I greatly doubt it, for we find the first explosion was a very slight one indeed. Joseph Braggs and two or three others were 40 yards below the second half-way, and could hear the Lawtons talking, yet these men got safely out, neither did they see any flames. W. Roobottom was in the workings, and did not know that an explosion had occurred until he got to the pit bottom and was told so; therefore, if the explosion was so slight, how are we to account for stoppings and crossings being blown down? Even the crossing at the first half-way was destroyed, yet persons more than 400 yards lower downbrow safely came out.

When the first explosion occurred, the viewer's duty was to have superintended the restoration of the air in the downbrows, with all possible speed; one set of men should have nailed brattice cloth over the damaged stoppings, and another set of men followed after with bricks and mortar. The viewer is not at his post, and either from want of material, or some one to guide and put the workmen into that system and order which is required upon occasions like these, an hour and a half elapses, and another explosion occurs about One o'clock, rather more destructive than the last, but far from being a very violent one. John Winter was at the first half-way when it occurred, and got out with difficulty. This, as well as the former explosion, would be the most severe, and its effect would be the most felt in the neighbourhood of the engine-plane; it being the only opening to the external atmosphere, from whence, without the agency of elasticity the vacuum could be supplied that had been occasioned by the explosion, condensing and changing the chemical union of the gases, and thereby creating contraction and expansion; yet, in both explosions, men escaped who were in the brow. The cause

which led to the explosions, was the lighting of blowers of carburetted-hydrogen gas, which issued from the cleavage fractures of the mine. These were kindled by a fuse that was used to explode, or fire a shot in the backbrow, or the return of the dip-bords.

Joseph Walton fired a shot about half-past Nine, in the straight bord or intake side, and in a quarter of an hour after, he fired another in the back-bord. When the fuse was lit it fired the gas, and after the shot exploded, they endeavoured, for three-quarters of an hour, to extinguish the flame, but in vain, for it set fire to the bratticing, and compelled them to leave it. Henry Lawton arrived some time after, and endeavoured to build a stopping in the return, but the smoke was too strong; he now closed the door which I have previously described, and shortly afterwards, the first explosion occurred about half-past Eleven. I am strongly impressed that it was the closing of this door which caused it, and nothing else. Mr. Madison's theory of it is, that—"after the "coal got on fire, the air would become vitiated, and would "pass naturally up to the cupola shaft. The combustion "going on at the dip-bord faces, would yield a stifling atmosphere. "The fire having burned for two or three hours, and the "full force of the current of air being upon it, the heat would "increase to such an intensity, that it would be a burning "furnace of coal to a considerable distance; as soon as Lawton "succeeded, which he probably did, in putting in the stopping, "the result would be this, that instead of the gases being "consumed as they were generated, the whole of the burning "mass would be converted into a huge retort, the gas and other "vapours generated, would all pass forward to the cupola shaft. "It has been stated, that there were 30 or 40 naked lights, and "any one of them coming in contact with the gas thus produced, "would ignite it, and hence the explosion." Mr. Madison does not name any gas that is likely, in his opinion, to have caused it, but this much is certain, that it must be one or more of the three

following, viz., carburetted-hydrogen, bi-carburetted-hydrogen, and carbonic oxide.

We know that coal contains about 5 per cent of hydrogen, and 70 to 90 per cent. of carbon, the direct result of its combustion is the production of these two elements. One atom of carbon unites with two atoms of oxygen, and forms carbonic acid; and one atom of hydrogen unites with one atom of oxygen, and produces steam; consequently it will be seen that if the fire in the dip-bords had received a proper supply of oxygen, the products of that combustion would be carbonic acid, steam, nitrogen, and some foreign matter, which I don't care to mention. But supposing that part of the fire that was the farthest removed from where the air entered, (for we may suppose the fire to be 20 yards long,) could not get oxygen sufficient, the carbonic acid would pass upon the incandescent carbonaceous matter, and there receive another atom of carbon, and be converted into carbonic oxide; but then again, it is known that carbonic acid will not support combustion, and the question is, would it not prevent the fire from spreading along the bord, after the oxygen became limited? for it is well known that a fire burns with difficulty, when placed to the windward of another. I am inclined to think that this fire could not extend to the dimensions that have been assigned to it, for it was 500 yards removed from the second halfway, and there was nothing for this distance but one drift, for it to spend its fury upon. Then again, if the fire did give another atom of carbon to the carbonic acid, which it would not unless it retained a certain heat, the carbonic oxide produced would ignite at another part of the fire that it would have to pass over, and again be converted into carbonic acid, and by this means, the process might be repeated scientifically for any number of times; nevertheless my opinion is, in practice, that a fire, under circumstances such as the one in question, could not possibly give off carbonic oxide to account for the explosion. Then, if this be so, we have now to consider the carburetted-hydrogen and olefiant gas; the former is

composed of one atom of carbon, and two of hydrogen, and the latter, by the addition of another atom of carbon, to the carburetted hydrogen; both these gases are produced from coal; but as the heat necessary to produce them in open fires is always sufficient to explode them as they are generated, if sufficient oxygen be present, and convert the same into carbonic acid and steam. Should there not be enough of oxygen, then there will undoubtedly escape both the above gases, but in small quantities only, especially the olefiant gas, which explodes at a less temperature, but requires another equivalent of oxygen as compared with fire-damp.

From the foregoing it will be seen that the carbonic acid given off, would be more than sufficient to render negative the explosive gases which might escape, one-seventh being sufficient to destroy the most destructive mixture. Then again, supposing it possible for explosive gases to have been volatilized from the coal, which can only be assumed to have arisen from the absence of oxygen, consequently the very thing which caused their production, would prevent them exploding. It is true that atmospheric air would be supplied to this dip-bord split from the returns of the north and south workings, but this would be between the upcast and the first half-way, and if an open light had been introduced into it between this point and the shaft, the explosion would have been the greatest in the vicinity of the shaft, whereas we find it not to have been the case, but that it was confined to the immediate neighbourhood of the fire.

Mr. Madison attributes the second explosion to the restoration of the crossing at the first half-way, thereby throwing the air down upon the fire below. Let us see how this is borne out. If the crossing at this half-way was destroyed, and the stoppings blown out near the shaft, it is more than probable that the stoppings below the first half-way, and the crossing at the second half-way

would be blown down also, which would prevent the air reaching the fire, even after the crossing of the first half-way had been restored; but we have no evidence to show that this was the fact. If the air had by this means been thrown on the fire, it would only have tended to the more complete combustion of the gases. My opinion is, that this second explosion could not be caused in this manner, for the simple reason above stated; but rather that it was caused by the gases in the goaves of the second half-way being put into circulation by the first explosion, and then brought into contact with a collier's open light; for the mine was worked exclusively with open lights, except the dip-bords. The evidence of John Guest, fireman, discloses that "there was gas in a bank or "goaf in the second half-way, and if he went far enough into it, it "would explode in the lamp. This was about 20 yards behind the "men. If there had been a sudden fall of roof, it would have "probably forced the gas upon the men's open lights; he had "informed Lawton of this, but he did not send the open "lights out."

When the second explosion occurred at five minutes to One, Mr. Mitchell, Jun. went and fetched Mr. Madison, who arrived at the colliery about five minutes past One. Mr. Mitchell, Jun. told him that the furnace fires had been put out; but to make sure of this, Guest and Clegg, at the request of Messrs. Madison and Mitchell, (who were then holding a consultation in the office,) were sent down to see whether the furnace fires were out or not, but they could not get nearer than about 10 yards; and when they came up reported the fires were out. I should certainly have been astonished if the furnace fires had been found in, as James Shigley, the furnace man, left the fires at a quarter to Eleven in consequence of the smoke, came out of the pit and reported it to Geo. Lawton, therefore there had been no fuel put on the fires for three hours, and moreover, the cinders had been swept out by two explosions, as attested by the persons who were at the shafts'

bottom when the same occurred.—Mr. Madison and a party of eight men went down the pit at half-past Two o'clock.

It will naturally be asked what had been done since One o'clock? The answer is—nothing beyond a consultation, which had now been held for about one hour and a half. Was the question of how to rescue the 52 unfortunate individuals of so difficult a nature as absolutely to require this time? certainly not. There was only one method to adopt, viz., the repairing of the crossing at the shaft, sending all the air into the downbrow, and rebuilding the stoppings and crossings therein, and by that means to restore the ventilation, and liberate the persons. However, they descended the shaft as above stated, and found the main crossing from the downbrow blown out,—this crossing carries the return air from the downbrow over the shaft level,—and they found smoke coming up this downbrow, and going to the upcast shaft. There could be very little smoke coming up, as the air from the downcast shafts, would fill this return completely full, and virtually lay stagnant all the downbrow workings. Mr. Madison and party, without attempting to restore this crossing, or put a stopping in the level which would have answered the same purpose, proceeded along the downbrow intake, and succeeded in getting about 120 yards down, and passing six stoppings which are at intervals of 20 yards; four of them they found more or less blown down, one remaining good, and the last completely demolished; and upon Clegg, one of the party, going a little further down, he was lost sight of, the smoke being so dense.

"The atmosphere (said Mr. Madison) was so stifling and "choking that it was impossible to get further. The gases were "of such a nature as to indicate they proceeded from burning "coal,—it was similar to passing up a cupola shaft with a heavy "fire on—he would not certainly recommend that the ventilation

"should be restored, unless he wished to commit suicide and "produce certain death;" some of the party suggested it would be desirable to restore the ventilation; Mr. Madison pointed out if they restored the stoppings it would bring the air down to the furnace, and cause another explosion. Is it possible that Mr. Madison could have used this expression to men who were naturally looking upon him as their leader. Surely Mr. Madison had satisfied himself before he went down, that the furnace was out, as Mr. Mitchell, Jun,, told him it was put out. He sent Clegg down the pit, who reported it was quite out. This was shortly after One o'clock; and yet, at Three o'clock, he says, he dares not restore the ventilation, in fear of the furnace. Mr. Madison then asked them all round if they believed there was anyone living in the pit except themselves; three said they had not been far enough to judge. The persons' names ought to have been given to the public, as they evidently understood the duty required of them as Englishmen. They had previously been over-ruled with regard to the restoration of the ventilation, and now they could not give their sanction, until they had removed—or endeavoured to do—the barrier which prevented their comrades' escape, viz.:—the clearing of the downbrows of carbonic acid and nitrogen, which were stagnant, or, as Clegg said, "the ventilation was stopped." Mr. Madison replied, "it would only take them a minute, and he would rather they were satisfied;" which was equivalent to saying—go into the gases as far as you like, but do not try to remove them,—of course they came back, and said they were satisfied.

Did Mr. Madison believe that because he found the downbrow full of smoke, it followed that all the downbrow workings, benks, blows, levels, &c., were full also? If he did so, and I am undoubtedly of opinion that such is the fact, he is more to be pitied than blamed, and the responsibility rests with those who brought him to this colliery, and put him in such a responsible position, responsible indeed so far as can be gathered from evidence; but I ask

where was the viewer of Edmond's Colliery? we have proof sufficient that Geo. Lawton was only a foreman of the colliers, or underlooker. I am fully persuaded that he acted upon the orders of the viewer. G. Lawton told Walton on the morning of the accident, that "he (Lawton) was afraid something would happen, and he "wished he had driven through to Swaithes, as he was very uneasy "in his mind." Does not this bear evidence that there was some pressure put upon him from somewhere? what motive had he in pushing the downbrow so fast? not because he wanted more air, for it was proved that the workings, so far as the air traversed, were better ventilated than nine-tenths of the mines Mr. Brown had known. Did the viewer want to make Swaithe Pit into a coal-drawing shaft, in order to raise a large quantity of coals, and to facilitate this object had he given Lawton orders to work incessantly this dangerous part of the mine, and to stimulate the men to exertion, give them a bonus if they cut a certain number of yards, and by this means open a large number of cleavage fissures in quick succession, which were admittedly filled with gas, and before one was drained another would be opened, making the immediate neighbourhood of the face a complete series of blowers? Viewers do not personally give instructions to the colliers, but these are given through their underlooker, nevertheless, this plan does not take the responsibility from the viewers. Then, if we are satisfied there was a viewer at the colliery, it is he who is responsible for the proceedings that were taken after the explosions. Mr. Madison said, in his evidence, that after the explosion took place,—"The air-crossings "would be destroyed, the whole of the gases and after-damp would "mix, and there would be no ventilation whatever below the first "half-way." This is correct so far only as where the explosion took place; but in the other parts of the workings, the air would remain the same as it was before the explosion. The nitrogen and carbonic acid would take their relative positions according to their specific gravities; and were it not for a property which they possess, called diffusion, one might live within a very short distance of the same with perfect safety. In colliery workings of large extent, it might

and of all things, I condemned, in those lectures, the mixed use of lamps and naked lights. The words which I made use of were these: "The mixed use of Davy-lamps and candles in a mine, where fire-damp is known to be in any part of the works, is, to say the least of it, both reckless and dangerous." I do not know how it is that in most of these Yorkshire mines, they use mixed lights yet; and it is on that point I wish to ask Mr. Goodwin whether he calls it good management of a colliery in having the two descriptions of lights in use in a mine?

Mr. Goodwin—I should condemn the system at once; but in this case there were very few lamps used, and those were in a separate part of the workings. The majority might be said to be working by candles, and the mine was generally worked by candles. If I had my choice to-day, I should do the same in many mines. I have seen a good many collieries, and managed more than most people, and I would sooner take the candle to-day, with all its failings, than the Davy-lamp, where the getting of coal is not properly conducted. Of course I do not say the candle is safe in the hands of everyone; but, with careful management, it will do a good deal, and is much better than many suppose. It is making these places a huge receptacle for gas that forms the danger.

Mr. Binney—Hence the danger of using candles.

Mr. Goodwin—I have seen collieries well and safely managed with them. As for accidents in collieries, they are unavoidable as long as mining operations are undergone. I beg now to move that Mr. Farrimond's paper be discussed at the next meeting.

Mr. Binney—Perhaps we had better leave that to the Secretaries, who have the making of the arrangements.

The thanks of the Society having been voted to Mr. Farrimond for his paper, the meeting broke up.

as quick as you can, and as much as you can." This was about half-past Three o'clock; and at Four o'clock, Benjamin Clegg and others, were sent down the shaft, and rescued nine horses. I should have been rather chary in recommending this dreadful course of drowning the mine. The viewer ought to have taken the initiative, and not have shielded himself behind a person unacquainted with the works. Nevertheless, I consider that however indiscreet Mr. Madison may have been, yet it is the viewer who is responsible, morally, if not legally, though he did stand in the back-ground. In a leader of *The Colliery Guardian*, of the 27th ultimo, upon the Edmond's Main explosion, the following occurs,—"A system "prevails, not only in Yorkshire, but in many other districts, of "dividing the management of the under-ground operations of a "colliery, between a consulting viewer and foreman of colliers,— "such as in some localities, is styled an overlooker. The former "visits the colliery only occasionally, when he inspects the plans, "and prescribes the course of operations; but the actual supervision "of the mine is left to the under-viewer, who resides on the spot, "and descends into the mine every day. There are many advantages "attendant upon this system, but all of them in our opinion are not "equal to that of having a properly qualified manager always at "hand to meet emergencies." The only conclusion to be gathered from this is, that the viewer of Edmond's Main was a consulting viewer, and from this circumstance I think it rather singular he should have been at the colliery at the very time this explosion happened; therefore the benefits arising from the manager being at hand did not avail much, as the consulting viewer was at hand, and from the varied experience gained from not being confined to one colliery, the best of results would follow one would have naturally thought; such, unfortunately, was not the case; whether it arose from his giving place to another whom he could place more confidence in than he could in himself, I know not.

Again, in the same leader, and preceding the last quoted, we read,—"George Lawton himself confessed on Monday Morning that

"there was danger, and therefore he should either have remained "himself in the locality, and superintended all operations, or he "should have given precise instructions to others, telling them in "particular what to do, should there be a large effusion of gas, and "the coal again take fire." It will be seen that even *The Colliery Guardian* admits that it is impossible to be always at hand, and even recommends the underlooker to give precise instructions should the coal again take fire. The consulting viewer should have taken a different course; after hearing on Saturday of the fire which had taken place that day, and knowing that there had been one on the Thursday previous, (the underlooker having to report immediately anything out of the ordinary way,) he would have given strict orders that the place should be worked with safety-lamps, and that not only the colliers, but all who had occasion to enter this place, should use safety-lamps, and that the firing of shots should be discontinued.

If the underlooker had been at the fire he could have done no more than was done, viz.—beating it with their jackets, and throwing wet slack upon it; he might certainly have prevented the brattice getting on fire, and, as a last resource, pulled it down, and by this means taken the air off it. Seeing then that it is impossible to be always at hand, the argument used by *The Colliery Guardian* is not tenable. I know that we have gentlemen of great practical ability, and scientific attainments, holding situations as resident viewers, with honour to themselves and satisfaction to their employers. It is equally true we have mechanics, carpenters, &c., and an innumerable host of book-keepers, holding the same situations. We have again managing partners and owners, acting as viewers, and these, it is well known, let their previous occupation be what it may, viewers they will be, so soon as they become connected with a colliery. It is this class of viewers, as a rule, that we find are the most unfortunate. I think every person has a perfect right to see and examine in what manner of way his money is being spent; but I do say, if anything unpleasant should occur,

they should bear the brunt of the same in the proportion they have had in the management, and not, upon these melancholy occasions, invest the underlooker with that unenviable post of sole manager. These persons would do well to secure the services of a consulting viewer, to act between them and the underlooker; they each can, by this means, keep their relative positions, and yet have the colliery worked with satisfaction and safety; and if there is one thing more than another which Her Majesty's Inspectors of Mines can do with satisfaction, and benefit, alike the employer as the employed, it is to ascertain the mode of management and to volunteer advice, and not as is imagined by some, to try how many thousands of miles they can travel in the winding galleries of our mines during two or three years.

The resident viewer of a colliery, in nearly all cases, has to manage other departments besides the working of the colliery,—such as that of secretary, book-keeper, salesman, &c., according to its extent, and seldom goes into the workings more than once a fortnight. The consulting viewer, though he may not visit the mine quite so often, yet possesses greater practical experience from devoting his time solely to one object, and the chances are, he will be more successful in guiding its operations.

Mr. Goodwin—It would be much better were a discussion on a subject like this to be kept back for another meeting. There are many points in the paper which require careful consideration before we can speak with that certainty and assurance that Mr. Farrimond has done. In reference to one point, however, I must say it makes no difference in reponsibility if a man choose to work for 30s. or £5 a week. The question is rather one of ability. Mr. Farrimond in speaking of the resident viewer, has so used the term, having mixed it up both with the duties of secretary and

many others, that I can hardly tell what he means by it. But I presume it means that he shall take the charge of a certain concern, or number of concerns; he shall go and examine them, no matter whether every day, every month, or every three months; and he takes the responsibility of guarding against accidents. I know many persons who like their collieries managed by people who will be upon their place regularly, to watch their interests in a pecuniary sense. I have no objection to viewers myself, but I should like to ask Mr. Farrimond whether, if a person is capable of managing ten or a dozen collieries he cannot manage one well, and whether the duties of managing a colliery are so light as not to demand the attention of one viewer? I would much rather the discussion was waived to night: it is very important. I do protest against adding insult to injury by thus bringing forward the name of George Lawton, and speaking of his incompetency, while he has paid the penalty of death. I know something about the colliery in question, and I have thought a good deal upon the subject, and I have no hesitation in saying that it was worked as well as many others in the same locality. I have carefully examined all the particulars, and this is my conclusion.

Mr. Binney—Do you mean to say, that you, as an experienced colliery manager, sanction the mixed use of safety-lamps and naked lights, in a mine like that, which was allowed in this colliery?

Mr. Goodwin—I did not say that I did, nor should I have used them myself, because of the quantity of stored-up gas that surrounded the workings. We cannot class this as a mine that was generating much gas, for the naked candle was generally used there. It is a question that admits of a variety of views, whether the system adopted was a good one or not. But I must say I was

somewhat astonished to find Mr. Farrimond condemning the pillar and stall system, which at the last meeting he advocated, and now he is asking for it to be removed.

Mr. Farrimond—I advocate the long-work system. I have introduced it into two collieries, but had much difficulty in getting it done, having in fact to pay the colliers an extra amount to do it. Now, however, they are quite used to it, and I could not persuade them out of it, if I tried. By this method, in suitable mines, a colliery can be worked cheaper, and ventilated better.

Mr. Goodwin—It is quite premature to read a paper of this kind until the Coroner's enquiry had been finished, and until something had been proved to be radically wrong. In this case, there is no principle involved, as there was in the case of the Hartley catastrophe. I think, therefore, to say the least of it, it would have been much better to have allowed this matter to stand over. Mr. Farrimond has ventured to say that the next enquiry will be the same as the other; but I think it will be a very different affair.

Mr. Binney—I am sorry we have so very little time to discuss this subject; but we have had two papers. This is a paper of very great importance, and would well repay a long discussion. One thing I would remark: so far as I have seen about this explosion, and what has always struck me in these investigations, is, that both viewers, managers, and colliers, are but little acquainted with the nature of fire-damp. I am sure no men would run the risk of the loss of life and property, which is done every day, if they only knew what a terrible enemy they have to deal with in the shape of fire-damp. There is one thing in this, as in all other cases, we may learn, and it is respecting the mixed use of safety-lamps and candles in a mine. If there is one thing more than another to be deprecated, it is that mixture. Some years ago I took upon myself, though not so thoroughly acquainted with mines as I should be, to give some lectures to working colliers;

and of all things, I condemned, in those lectures, the mixed use of lamps and naked lights. The words which I made use of were these: "The mixed use of Davy-lamps and candles in a mine, where fire-damp is known to be in any part of the works, is, to say the least of it, both reckless and dangerous." I do not know how it is that in most of these Yorkshire mines, they use mixed lights yet; and it is on that point I wish to ask Mr. Goodwin whether he calls it good management of a colliery in having the two descriptions of lights in use in a mine?

Mr. Goodwin—I should condemn the system at once; but in this case there were very few lamps used, and those were in a separate part of the workings. The majority might be said to be working by candles, and the mine was generally worked by candles. If I had my choice to-day, I should do the same in many mines. I have seen a good many collieries, and managed more than most people, and I would sooner take the candle to-day, with all its failings, than the Davy-lamp, where the getting of coal is not properly conducted. Of course I do not say the candle is safe in the hands of everyone; but, with careful management, it will do a good deal, and is much better than many suppose. It is making these places a huge receptacle for gas that forms the danger.

Mr. Binney—Hence the danger of using candles.

Mr. Goodwin—I have seen collieries well and safely managed with them. As for accidents in collieries, they are unavoidable as long as mining operations are undergone. I beg now to move that Mr. Farrimond's paper be discussed at the next meeting.

Mr. Binney—Perhaps we had better leave that to the Secretaries, who have the making of the arrangements.

The thanks of the Society having been voted to Mr. Farrimond for his paper, the meeting broke up.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 5.] VOL. IV. Session 1862-63.

The monthly meeting was held in the Museum, Peter Street, on Tuesday, February 24th.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

The President announced that there were two papers to be read, in addition to which the discussion on Mr. Farrimond's paper on the "Edmond's Main Explosion," would be resumed.

Mr. J. Taylor, Jun., said he wished to correct a mistake which had crept into the last discussion; it was on page 84. He was made to say that there was a series of coal-measures upon the limestone. He did not say this. What he did say was, that there was limestone, and no coal-measures on it. Mr. Taylor also announced that he had discovered some fossil shells in the drift near the Stockport station.

Mr. Whitaker produced two horses' teeth and a flint arrow head, which he said came out of the drift gravel at Barrowford, a few miles north of Burnley.

The President—I see by the notice paper that our first business is to hear a paper from Mr. T. T. Wilkinson, F.R.A.S., on the "Drift Deposits near Burnley." I would therefore propose that any remarks which might be suggested by the specimens which Mr. Whitaker has laid upon the table should follow the paper, which will no doubt touch upon the subject more or less.

ON THE

DRIFT DEPOSITS NEAR BURNLEY;

BY T. T. WILKINSON, F.R.A.S., &c. &c.

The drift deposits in the neighbourhood of Burnley, as well as those near Manchester, appear to possess several features of considerable importance, for, in addition to the usual clay and gravel, they contain pebbles and masses of foreign rocks, some of which are well water-worn, whilst others are so fresh and angular as to admit of scarcely any other explanation of their presence here than by iceberg-carriage from a great distance. Encouraged by what Mr. Binney has stated and done in p. p. 8, 9, and 351 of the third volume of the Transactions of this Society, and elsewhere, I beg to offer a few remarks on those deposits which have recently fallen under my own observation.

A little east of the Four Lane Ends, near Blackburn, 650 feet above the level of the sea, the drift immediately overlies the Rough Rock, which crops out above the Corporation Park at an angle of about 75°. On the crest of this hill the blue clay, from which bricks have recently been made, lies upon the surface. It is, however, too much intermixed with sand from the disintegration of the rock to form good bricks. The pebbles and boulders contained in the clay appear mostly to belong to the carboniferous formations, and their water-worn appearance indicates long-con-

tinued denuding action by water. Both limestone and gannister pebbles occur in abundance, the former of which must have been drifted from a considerable distance.

Extensive deposits of yellowish sand occur opposite Portfield, near Whalley, 196 feet above the level of the sea; at Whittle Field, near Burnley, 451 feet above the level of the sea; and also at Healey Hall, on the slope of Burnley Moor, 580 feet above the level of the sea, masses, or veins, of hard carbonaceous matter are occasionally found in this sand, probably indicating the remains of former vegetation; but I have not yet been fortunate enough to detect any shells in these deposits.

At the Quarry, near Habergham Hall, the sandstone rock immediately overlies the Dandy Bed of the Burnley coal-field.* The surface of the rock is here covered with a coating of soft loamy shale, which soon passes into clay on exposure to the atmosphere. This shale is almost wholly composed of calamites, ferns, sigillaria, &c., indicating a profuse vegetation, which must have been covered by succeeding deposits in comparatively stagnant water. Above this shale there is a bed of dense blue clay, 22 feet thick, containing fragments of cannel, coal, &c., the debris of still higher strata. Rough rock and grit boulders, portions of encrinital limestone, sometimes water-worn, together with rounded sandstone and limestone pebbles, occur in abundance, imbedded in the clay, and the whole is surmounted by the remains of the denuded rocks which once occupied the next position in ascending order.

In the Quarries, near Sandy Gate, Habergham Eaves, 462 feet above the level of the sea, the drift is from 30 to 50 feet deep. It consists of dense blue clay at the bottom, and gradually passes into dark brown near the top. Large boulders of sandstone,

* See page 134 of Mr. Hull's excellent work on "The Coal Fields of Great Britain," 2nd edition, 1861.

similar to that which lies beneath, occur in these deposits, few of which appear to have suffered from the action of water. From their positions in the clay it may readily be inferred that they may have fallen from the faces of the cliffs which then probably bordered the ancient seas. Portions of encrinital limestone also occur; and there is no lack of rounded fragments of cannel, together with sandstone, gannister, and limestone pebbles.

In similar drift at Swindon, about two miles east of Burnley, 800 feet above the level of the sea, and just under the Pennine chain, large boulders of New (?) Red Sandstone are occasionally found in connection with abundance of rounded limestone. In former times the farmers have washed the drift in Swindon valley, and have burnt the limestone thus obtained in kilns, the ruins of which still remain in several places.

During the formation of a main sewer in Trafalgar-street, Burnley (1862), the workmen found a large boulder of grey granite. It was firmly imbedded in yellowish clay at a depth of about 15 feet from the surface. Encrinital limestones were also plentiful in this cutting. These deposits overlie the Thin Mine of the Burnley top beds; the Cannel Bed, which is the next in ascending order, having apparently been washed away.

In various localities extensive pebble beds occur, indicating former beds of rivers, or the margins of ancient seas and lakes. Several of these bear evidences of powerful currents, which, from the set or inclination of the pebbles, appear to have flowed across the country in a N.E. to S.W. direction. This is very evident from an examination of the inclination of the debris in most of the sections previously noticed, but especially in one which exposes a portion of the grit series between Haslingden and Helmshore. This inclination of the stones found in pebble beds, and drift deposits generally, appears to me to be capable of affording more

information to geologists respecting currents, &c. than has yet been noted; and hence I would suggest more attention to this circumstance from observers than has yet been bestowed upon it. Prior to the upheaval of the Pennine chain a broad strait must have stretched across portions of Lancashire, Yorkshire, Durham, and perhaps Northumberland, thus connecting the present German and Irish seas; and the current through this strait must have run from N.E. to S.W., as indicated by the inclination of the pebbles and boulders in these drift deposits. Portions of floating icebergs from the north of Scotland broken off from the edges of the glaciers, and charged with portions of granite and the older rocks, would then find their way down this channel, and becoming stranded in the shallow bays, would drop their cargoes of boulders among the silt at the bottom of the turbid waters. Red sandstone boulders might perhaps be drifted in a similar manner from the neighbourhood of the Tees, or from the cliffs of what is now the Vale of York. Encrinital limestone, not water-worn, might also be transported from the north by the same mode of iceberg carriage, to the deposits in which they are now found. Or again, if we adopt Sir Charles Lyell's and Mr. Hull's conceptions of the wasting of a vast North Atlantic continent,* the same results would evidently be obtained.

On the gradual upheaval of the Pennine chain, the sea would consequently retire, both on the eastern and western sides of the country, leaving behind it those significant terraces which may be seen on the slopes of the hills abutting on the valleys of the Calder, the Hodder, the Ribble, and the Irwell from about Ramsbottom to its various sources. The contents of these drift deposits also indicate several widely different conditions of things. There must have been many quiescent periods, and also many gradual depressions of the surface during the formation of the various

* See Mr. Hull's "Coal-Fields of Great Britain," 2nd edition, p. p. 252-3. Also Lyell's "Elements," vol. 1, p. 431.

coal-seams and the deposition of the rocks and shales by which they are overlaid. After the latest deposits there must have been a gradual upheaval, with occasional fractures, from the bed of a deep ocean, and, as the bottom came nearer the surface, the more powerful would be the currents, and hence the variable, but extensive denuding action of water which is everywhere apparent.

There is, however, good evidence that within the historic period the coast of Lancashire, at least, has again undergone considerable depression. In the times of the Romans there was probably no estuary of the Mersey. Ptolemy does not include this now important opening in his topography of the coast. The dredging operations at Liverpool continually afford proofs of recent land surface; and even hazel branches, containing nuts, were dug up from a considerable depth during the formation of the Sandon Dock. Along the shore from near Formby towards Preston, there are the remains of an extensive ancient forest. Many trunks of trees were exposed during the formation of the East Lancashire Railway, and are still to be seen in the pools on each side of the road. The roots of these are mostly below high-water mark, and in some places the trunks extend into the sea; but all of these must originally have flourished at a much higher elevation. About Southport they are so numerous that they have been used to form ornamental fences for some of the gardens.

At Blackpool, and on towards Fleetwood, the sea is washing down the cliffs at the rate of about one yard in breadth per annum; and tradition states, on very probable grounds, that nearly half a mile in breadth of this part of the Lancashire coast has disappeared within the last hundred and fifty years. There are therefore strong reasons for supposing that Lancashire is at present undergoing a gradual depression. In Scotland, on the contrary, according to Mr. Geikie, the reverse operation is in progress, and it may form an interesting subject for some speculative mathematical

geologist to enquire whether this apparent flexibility of the earth's crust is due to internal local action, irregularly applied, or whether it is the natural result of those mechanical laws which govern the earth when considered as a comparatively solid film resting upon a fluid interior.

A vote of thanks was unanimously passed to Mr. Wilkinson for his paper.

The President said the subject was now open to discussion.

Mr. Hull—These discoveries of marine shells in the drift are very interesting; but we have also in this neighbourhood the more recent gravels of the valleys. These are of later date, and, according to the judgment of some, are most undoubtedly of the same age as the Amiens and Thames valley gravels, and many others which are yielding works of human art in different parts of Britain and the continent; and I think it is very important that the attention of local geologists should be turned to the subject, because there is no reason, as far as we can see, why our river terraces here should not yield flint implements and the remains of some of the extinct mammalia which are found in some other parts of the country, and appear to have been contemporary with man. With regard to this paper, it seems to be one about the drift of other parts of Lancashire as well as Burnley. There is a number of things which have been stated before, especially the mention of the sunken forest along the coast of Lancashire, that has been in print for several years. In general it is a misfortune when a local paper expands into generalizations such as those in the paper before us. They can lead to no good results. The great object of all local observations should be to give true and definite facts and

phenomena, upon which generalizations might afterwards be grounded. I almost feel inclined to protest against every local paper on the subject of the drift branching out into speculations about the amount of subsidence and elevation of the earth's surface, and so on. They are quite out of place. I wish Mr. Wilkinson had been able to classify his observations in the neighbourhood of Burnley better. With regard to the new red sandstone boulders which he says are 800 feet above the sea, of course it would be improper for me to say they are not of this formation, but the identification is very questionable. I do not think the new red sandstone in the north of England attains to such a height. To suppose that boulders are carried from a lower level to a higher is a very unlikely thing indeed, except in the special instance of coast-ice. These sandstone boulders are much more likely to be old red sandstone or millstone grit. That they have been brought from the vale of the Tees and across the Pennine chain in their course to a higher level is, I think, extremely improbable. I need not say we are much obliged to Mr. Wilkinson for the facts he has given us.

Mr. Binney—I think I first suggested to the gentlemen about Burnley to investigate their own neighbourhood, and therefore I may be expected to say a few words. I was anxious to get a knowledge of the drift deposits about Burnley; and some two or three years ago I requested those gentlemen to collect all the information that could be obtained about their own district. Therefore I am glad to see Mr. Wilkinson and others have taken notice of what I said. I agree very much with what Mr. Hull has said about these wide generalizations. My advice to them about the collecting of information was this,—that at every opportunity, the cutting of a road, the sinking of a pit, and such operations, they should collect good details of all the strata gone through. That is the most valuable service any gentleman can do in getting up information with regard to drift. In case a drain is being made, a road cut, or a well sunk, there is a capital opportunity to

get details of every bed that is passed through, with the height above the level of the sea where those excavations have been made. Just collect a series of valuable facts, and then we can enter into hypotheses and generalizations as to the causes of the phenomena. Mr. Whitaker has brought some of the veritable red sandstone, which I have no hesitation in saying is millstone grit or Rough Rock from the neighbourhood.

Mr. Whitaker—The ravine from which these stones have come I know well. They are making a reservoir there, and the water manager, at my request, brought down these boulders from the same heap that Mr. Wilkinson had examined. The course of the stream from its source in the hills to the place at which the boulders were met with runs over the outcrop of the millstone grit, many seams of which cannot be distinguished from these so-called new red sandstone boulders, but which in my opinion are nothing more than pieces of grit torn off and rounded by the force of the torrent; and so long as we have rocks near home that will account for these boulders, I do not think we are warranted in going hundreds of miles away for them. If it be new red sandstone, you can not only find it in any quantity as boulders, but you meet with it in any quantity *in situ* in the lower coal-measures. If I understood Mr. Wilkinson rightly, he speaks of the boulder clay having been deposited previous to the upheaval of the Pennine chain; but, from my own observations, I have arrived at an opposite conclusion, namely, that the land had much the same configuration then as now, with the exception of standing at a much lower level with regard to the sea. If, as stated by Mr. Wilkinson, the drift had been deposited upon a level plain, and the upheavals had taken place afterwards, the hills would have taken the boulder clay up with them, and we should have found it upon the tops of the highest of them. But such is not the fact. I can trace the drift to a height of from 13 to 1400 feet, but no higher. Still there is evidence that the sea of that time reached a

height sufficient to submerge hills of from 15 to 1600 feet. On Boulsworth, for instance, there are large numbers of enormous boulders, some of which, right on the crest of the hill, some 1600 feet high, are furrowed and grooved almost like gridirons, as if the icebergs had been stranded in floating across, and had grated upon the rocks strewn upon the bottom of the sea. But on Pendle we have an entirely different appearance. On the top we have no drift nor any of the very large boulders that we find on Boulsworth. I have also seen growing on Pendle the semi-arctic plant, *rubus chamæmorus*, which, according to the theory of the late lamented Professor Forbes, may be a relic of the flora that flourished during the period of the glacial sea. I have seen the same plant on Whernside and Ingleborough, but I have not been able to meet with any traces of it on the lower ranges of hills, such as Bouldsworth or Hameldon, hence I think it is not improbable that hills of from 15 to 1600 feet in height were submerged, but hills that approached to, or reached over, 2000 feet stood out as low islands in the cold and dreary sea of the drift period.

Mr. Hull—What is the height of Pendle?

Mr. Whitaker—Something over 1800 feet.

Mr. Binney—The flint which Mr. Whitaker has now exhibited he showed to me this morning. We see that it is a flint having certain chippings; and it may be taken as a moderately good example of an ancient arrow head. It is of the same character, though rudely formed, as those which have, without question, been made artificially. I have seen many in collections not much more perfect than this. It was found in the valley gravel beyond Barrowford, and it is the very place where Mr. Prestwitch and I have been looking for them for some time. At present I have found none of them in Lancashire. I should not like to say

positively that this has been a portion of an arrow head; but it is more like than any other flint I have yet seen in these beds. It is a chalk flint, and such are very rarely, if ever, found in these valleys. I think they will be found in the gravel near Manchester, but you may look a long time before you are successful.

Mr. Whitaker—I have a notion from the materials that were taken out that these workings would have yielded something of greater interest than what we have got. There is another thing I must just mention. About a few hundred yards further on, in the same valley, in sinking a foundation for a chimney some years ago, the workmen found several deer's horns and some bones, but they have probably been destroyed now.

Mr. Taylor—Can the specimens which we find in the gravel in this district be flints, seeing that no flints are known to exist in the north?

Mr. Hull—In some cases it can be shewn that the materials for the construction of arrow heads and other such implements were brought from a great distance—some hundreds of miles. There are some articles of stone, the works of human art, in Switzerland, which must have come from the shores of the Baltic. It is quite possible therefore that the flints found in this neighbourhood may have been brought from other districts.

Mr. Taylor—The implements which have been found in later deposits in Scotland are of a different character.

Mr. Binney—They vary very much.

Mr. Hull—It is not at all impossible that common flint pebbles should occur in the valley gravels in Lancashire.

The President—There is nothing different in this flint from that might have been produced any time if you broke a stone with a hammer.

Mr. Binney—In some antiquarian collections which I have seen, the arrow heads are quite as rude as this flint produced by Mr. Whitaker.

Mr. Atkinson—It is very much like an arrow head with the point broken off; a small piece added where the end is broken would give the appearance of a very good point.

The President—There are some excellent sections of this drift at Pepper Hill, near Clifton station. A large number of the specimens shown to me as flint implements I believe to be nothing more or less than ordinary pieces of flint broken accidentally into a certain shape. There is no evidence to show that they are arrow heads.

Mr. Binney—There is no question that a great number of the specimens collected from different localities both in this country and in France have been made by artificial means. It is a subject to which Mr. Prestwitch, Mr. Evans, and many other antiquaries have devoted a considerable portion of their lives; and when they come and give us the result of their investigations, I think we should receive their opinions with a little deference.

Mr. Atkinson—There are two terraces of gravel in the valley of the Irwell, which were mentioned by Mr. Binney in a former paper, that are likely places for flint implement to be found in.

Mr. Binney—Yes, I think so.

Mr. Atkinson—Is there any appearance of glacier action in

the locality of Burnley, of which Mr. Wilkinson speaks? I mean glaciers *in situ*, not floating ice.

Mr. Whitaker—I have not observed any glacial markings in the locality of Barrowford.

Mr. Hull—I do not think there is the least trace. At the same time, the sandstones and shales would very soon lose all appearance of glacial action, even if it once existed. The striations of the rocks have been destroyed if any ever existed. There is no appearance of moraines.

The President—Attributing this special action to icebergs, after all, I take to be only an hypothesis.

Mr. Hull—If you read Sir Charles Lyell's last work I think your scruples will be removed.

The President—Still I think Mr. Wilkinson is quite at liberty to express his own views as to these striæ, and I think he should not be tied or bound down to any particular hypothesis. There is no proof that there ever was any glacier action to contribute to this formation.

Mr. Hull—I think the proofs are not only so numerous, but so conclusive that there is no escape whatever from them. Any one who has visited the Welsh mountains, and compared their glacial phenomena with those of the Alps, cannot fail to come to the conclusion that there were glaciers at a former period. The striations of the hard Welsh rocks could have arisen in no other way.

The President—I myself have visited all these localities, but I have my doubts as to the glacial action forming these striæ. It is

a probable way certainly, but it should not be received to the exclusion of any other theory.

Mr. Binney—Gentlemen who for thirty years have investigated all these phenomena, and have visited different glaciers in Switzerland and Norway, and have seen pebbles striated there as they are in certain districts in this country, are, I submit, qualified to give an opinion on these matters. The only question is whether the opinion of a man who has studied this question so long is to be taken as of greater value than that of gentlemen who take it up for a moment just to pass an opinion upon it.

The President—I have seen markings that have been put down as glacial striæ that, upon being traced, have been found to have originated only from the side of a fault. Many such markings are put down to glacier action. The drift itself settling down on the side of a valley sometimes forms striæ, which are attributed to glacier action.

Mr. Hull—Although somewhat similar in appearance, those on the side of a fault are very different in reality.

The President then called upon Mr. Binney to read a translation of part of "Dr. Geinitz's work on the Magnesian Limestone and Lower Red Sandstone," by J. W. Kirkby, Esq., and himself.

Mr. E. W. Binney said—There has lately been added to the library of the Society an elaborate and highly valuable work by Dr. Geinitz, of Dresden, entitled "Dyas, or the Magnesian Limestone Formation and Lower New Red Sandstone." As this is probably the most complete work that has hitherto been published

on these interesting and important formations, through the kindness of Mr. C. F. Ekman, the indefatigable librarian of the Manchester Literary and Philosophical Society, I have been enabled to present to the Society a translation of the work, so far as it treats on England. Mr. J. W. Kirkby, a gentleman who has devoted much attention to the investigation of these strata in the North-east of England, has kindly added some notes.

As a considerable supply of coal is now obtained from under these strata, and year by year the sinking of collieries under them is likely to be greatly increased, and such supply much augmented, their study and investigation is as important as that of the coal-measures themselves. It was formerly believed by practical mining engineers that the coal-measures did not continue, or were much deteriorated, under the magnesian limestone. Both these suppositions have been amply disproved not only in the neighbourhood of Manchester but in many other parts of England; so it is now an established fact that these strata only cover, and in nowise injure, the coal-measures lying under them.

I do not intend to go into the merits of the battle between Dr. Geinitz and Sir Roderick Murchison as to which is the proper name, Dyas or Permian. Both of those gentlemen are competent enough to fight their own battles, and so I shall leave it to them.

The Dyas or Permian Formation in England.

(Translation from "Dyas," &c., by Dr. Geinitz.)

The attempt, after only a hurried visit to England, to draw a comparison between that country and Germany, will perhaps by many be considered presumptuous and inappropriate. I cannot, however, refrain from giving here also a sketch of the impressions made upon me by those geological features of England which I

have had an opportunity of observing, partly under the instructive guidance of distinguished fellow-geologists.

A clear view of the extent of the Dyas, or the Permian Formation of Sir Roderick I. Murchison and his fellow-labourers, may be obtained from a small but very accurate and practical map by that gentleman (Geological Map of England and Wales, 1858), and another fine map, on a larger scale, by J. A. Knipe (Geological Map of the British Isles and part of France, 1859). The admirably distinct district maps of the Geological Survey of the United Kingdom, under the superintendence of Sir Roderick I. Murchison, and the local direction of Messrs. Andrew Ramsay and J. Beete Jukes, are also rapidly advancing towards completion.

The Magnesian Limestone Formation (Zechstein Formation) of England resembles, in its general features, very nearly that of Germany; but in its details it presents several peculiarities. The German word "Zechstein" is not well suited to the English tongue, and has therefore, in England, been supplanted by the term "Magnesian Limestone," a designation which appears so far quite adequate, as the chief portion of the English magnesian limestone is very rich in magnesia. The fact is that in England the upper and middle groups of the formation predominate; and these are also in Germany remarkably rich in magnesia or talc.

The lower magnesian limestone, to which the compact limestone and the marl slate belong, contains, according to Sedgwick,* just as in Germany, very little magnesia, and has often no trace of it; as first pointed out by him with reference to Midderidge and East Thickley, on the Stockton Railroad. The compact limestone of Ferry Hill, on the contrary, contains, according to Kirkby,† car-

* Rev. A. Sedgwick, on the Geological Relations and Internal Structure of the Magnesian Limestone, and the lower portions of the New Red Sandstone Series, in their range through Nottinghamshire, Derbyshire, Yorkshire, and Durham, to the Southern Extremity of Northumberland, in Trans. of the Geol. Soc. of London, 2nd ser., vol. iii., part 1.: London, 1826, p. 76.

† J. W. Kirkby, on the Permian Rocks of South Yorkshire, in Quarterly Journal of the Geological Society. London, 1861, p. 323.

bonate of lime 54·1, carbonate of magnesia 44·7, sesquioxide of iron 0·6, and insoluble matter 0·6, thus in its chemical composition most nearly resembling the upper magnesian limestone of Hartlepool.*

The Rev. A. Sedgwick has given an admirable (equally lucid and complete) description of the lithological and structural character of the different members of the Permian formation in England. Sir R. I. Murchison (a), Professor W. King, of Galway (b), R. Howse, of South Shields (c), J. W. Kirkby, of Sunderland, E. W. Binney, of Manchester (d), and others, have more particularly determined the systematic place of each member in the general series, especially also in a palæontological point of view.

The Magnesian Limestone Formation of England may be tabulated as follows:—

(a). Upper Magnesian Limestone (Howse and Kirkby).

1. Laminated Dolomite and Conglobated Limestone, with many structural varieties in the North West of England, represented by red and green marls and shale with embedded plates and nodules of dolomite.

Syn. Crystalline and non-crystalline limestone (King); upper yellow limestone and conglobated limestone (Howse); yellow concretionary and crystalline

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* The percentage of carbonate of magnesia in the Lower Limestone of Ferry Hill does not appear to be exceptional for that member. Analyses, by Mr. E. J. J. Browell, of Lower Limestone, near Sunderland, and at Summerhouse, give the proportions of carbonate of magnesia and carbonate of lime, as 38·89 and 52·06 in 100 parts, and 38·88 and 56·40 in 100 parts, respectively.—J. W. K.

(a.) R. I. Murchison—Siluria. 1854 and 1859, &c.
(b.) W. King—A Monograph of the Permian Fossils in England. London, 1850.
(c.) R. Howse—Notes on the Permian System of the Counties of Durham and Northumberland, in Annals and Mag. of Natural History, 1857.
(d.) E. W. Binney,—On the Permian Beds of the North-west of England, in Memoirs of the Literary and Phil. Society of Manchester, 2nd ser., vols. xii. and xiv., and 3rd series, vol. ii, 1855, 1857, and 1861.

limestone of Marsden, Fulwell, Roker, Hartlepool, &c., Brotherton—limestone and lower red marl and gypsum of Brotherton, Knottingley, Womersley, Wadworth, Tickhill, &c. (Kirkby); red and variegated marls and limestone of Manchester (E. W. Binney).

(b). Middle Magnesian Limestone (Howse and Kirkby).

2. Breccicated Limestone, Dolomite and Pulverulent Marl.

Syn. Fossiliferous limestone and breccia (King); concretionary and shell limestone (Howse); shell and cellular limestone of Tunstall Hill, Humbleton Hill, Ryhope, Galley's Gill, Down Hill, Clack's Heugh, &c., small grained dolomite of Vale of Went, Lound Hill, Cusworth, Levit Hagg, Roche Abbey, Warmsworth, &c. (Kirkby).*

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* In grouping the magnesian limestone (proper) of Durham and Yorkshire in three divisions, Dr. Geinitz has chosen probably the best systematic arrangement that it is possible to adopt. It is certainly the most natural,—or the least conventional,—to these rocks, in both counties, where they are typically developed. Each of the three members is characterized by good lithological and structural peculiarities, as the learned author of 'Dyas, &c.,' has pointed out in respect to Durham; and as Mr. Howse had previously noticed when first proposing this tripartite arrangement. In each case, moreover, there are palæontological peculiarities which greatly assist in marking their distinction. But by including the marl slate of Durham along with the lowest of these sub-divisions, Dr. Geinitz appears to me to underrate its proper stratigraphical importance. For if it be simply viewed under its geological aspects it differs greatly from the limestone overlying it. Neither in composition, structure, nor general appearance does it in anywise belong to the limestone with which it has been placed. But it is not so much on geological grounds as on the palæontological features of the marl slate, that English geologists have been induced to grant it a full sub-divisional value. Its fossils consist principally of fish-remains; of these there are twelve species, only one of which passes up into the lower limestone. There are also three molluscs, and either two or three plants; the former occur in the limestone, the latter do not. Hence of the eighteen species forming the fauna and flora of marl slate only four are common to it and the lower limestone; the other fourteen, or more than three-fourths, being peculiarly and characteristically marl slate species. And if we view these fossils as a group they will be found to differ essentially from those of the lower limestone. In the latter we have an assemblage of species that are all of marine types, consisting of Mollusca, Bryozoa, Entomostraca, and corals. In the former we have fish and plants, with one or two shells of rare occurrence,—an assemblage significant of estuarine conditions rather than of such as were marine. The fauna of the lower limestone was certainly one that existed in a sea of some depth; the presence of articulated brachiopods, bryozoans, and corals, as characteristic fossils, indicates this. The life-group of the marl-slate was as evidently one that existed in shallow water,—

(c). Lower Magnesian Limestone and Marl-slate (Aut).

3. Compact Limestone (Zechstein proper).

Syn. Compact limestone of Pallion, Whitley, Pensher, Houghton-le-Spring, Ferry Hill, Thickley, &c. (Aut.)

4. Bituminous Marl-slate (as equivalent of the Copper-slate of Germany).

Syn. Marl-slate of Clack's Heugh, Down Hill, Midderidge, Ferry Hill &c. (Aut.)

5. Incoherent, mostly yellow sand, and friable sandstone, of Tynemouth, Clack's Heugh, &c., perhaps as an equivalent of the "Weiss-liegende" of Germany.

Syn. Incoherent sand (Howse).

1. The upper magnesian limestone is most imposingly developed in the North East of England, along the coast of Durham, between South Shields, Sunderland and Hartlepool. Its total thickness is estimated at 250 feet, which the corresponding strata of Germany have never reached. The upper "Zechstein" of Schlesisch-Haugsdorf and Kunzendorf at Neuland, in Silesia, is the nearest approach to it, in this and in many other respects.

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probably in an estuary, or near the mouth of a river, with land at no great distance; the occurrence of plants, and of shells belonging to *Lingula* and *Myalina*, and what we know of the fish-remains, all support such an opinion. It consequently follows, that the marl-slate and lower limestone, as deposits, have originated under very different physical conditions, and thus mark in Durham two distinct periods in the Permian era. For these reasons I think that Dr. Geinitz has not given to the former deposit the value, in the above tabular arrangement of Permian strata, which its importance demands. And in stating this opinion I merely support the views of those geologists—and more especially of Professor King and Mr. Howse—who have made the Permian strata of Durham their careful study.—J. W. K.

On the rugged coasts of Marsden Creek, between South Shields and Sunderland, which has obtained great celebrity for its picturesque masses of rocks, torn and excavated by the sea, and for the habitations cut out in the rocks by art, thin bedded laminated dolomites, mostly of a yellowish-white colour, are found in layers of considerable extent and aggregate thickness. They stretch in large wavy bands down to the foot of the Marsden rocks.

Some of the laminæ are slightly flexible, when fresh from the strata, and consist, according to Dr. Thomson (Annals of Philos., vol. iv.) of carbonate of lime 62·00, carbonate of magnesia 35.96, and insoluble matter 1,60.

Most of these dolomite plates correspond exactly with those of Schlesisch-Haugsdorf, and many other places in Germany. They are extensively used for the preparations of carbonic acid. The only organic remains found in these beds by my esteemed companions, Mr. J. W. Kirkby and the Rev. G. Abbs, of Cleadon, were *Schizodus Schlotheimi*, and *Aucella Hausmanni*. On the top of the laminated dolomite are layers of crystalline granules, and partly columnar dolomite, forming a transition to the beds of conglobated limestone, which occur at Fulwell Hill and Building Hill, near Sunderland, and have an exceedingly striking appearance. On the road from Marsden to Cleadon we found in such a course-grained dolomite, of a dark smoke-gray colour, several large specimens of the *Schizodus obscurus*, and the *Schizodus Schlotheimi*.

A breccia, in Marsden Creek, of sharp-edged fragments of dolomite, embedded in a cement of the same rock, is very interesting. It forms a regular dyke, 20 feet wide, which runs through the steep side of the rock. It is not improbable that its origin may have some connexion with the trap-dykes (Sedgwick, l. c. p. 62) which occur in the neighbourhood, and of which one at Tynemouth has long attracted attention. It is true this nearly perpendicular dyke, which runs from N.W. to S.E., has not actually cut through the limestone, unless indeed that rock, which is absent at the pla

of the dyke, should have been swept away at a later period; but the limestone has, however, suffered the same dislocations which may be observed in the strata of the underlying sandstone (Sedgwick. l, c. pl. 6, fig. 1).

The upper magnesian limestone on the coast of Roker, near Sunderland, varies from finely crystalline to earthy of varying shades of colour, with druses of bitter-spar or calc-spar, and appears in general to be very similar to that of Marsden. It is cut through by a number of cavities, which are said to extend as far as Monk Wearmouth, a suburb of Sunderland. The fine cliff consists partly of a most characteristic mass of spheroidal concretions of limestone of a yellowish-white colour, which has the appearance of a huge irregular pile of cannon balls and bomb shells of every calibre, cemented together.

The spheroidal concretions, which are found in several places on the coast of Durham, are stated by Sedgwick to contain a predominant amount of carbonate of lime, and, remarkably enough, very little magnesia, in which the regularly bedded and earthy varieties of the limestone, even in these localities, are very rich. According to Thomson (Ann. of Phil., vol. iv.), the upper magnesian limestone of Building Hill consists of carbonate of lime 56·80, carbonate of magnesia 40·84, carbonate of iron 0·36, and insoluble matter 2·00.

The varieties and peculiarities of the concretions of the upper magnesian limestone may be studied with advantage in the parks of Sunderland, as also, and more particularly, in the extensive limestone quarries of Fulwell Hill, near Sunderland. Structures of the most diversified forms, spheroidal, columnar, furcated, starlike, radiating, &c., and intersected by regular parallel or concretive-foliated layers, extend in immense numbers through several beds of the whitish or light-yellow rock, and afford to the eye an irresistible charm, representing to our imagination sometimes large stems of corals, sometimes an assemblage of artfully entwined

and sculptured objects.* In conjunction with them there are regularly bedded, finely laminated dolomites, of a light grey or yellowish grey colour, the sections of whose thin layers present a finely grooved appearance. Resembling the *styloliths*, these columnar concretions, repeatedly bi-furcated, in an acute angle, in the same manner as the cladocera, are generally grown fast with one end to the regularly bedded rock, whilst the free ends, which frequently bend accurately in the same plain, stretch up to the next lamina.

The upper magnesian limestone which I found exposed near the water-works in the neighbourhood of West Hartlepool,† is a similar laminated dolomite as at Marsden, of a small-grained, sometimes earthy structure, full of innumerable fine pores.

The upper magnesian limestone of Hartlepool consists of carbonate of lime 54·5, carbonate of magnesia 44·9, oxide of iron 0·3, and insoluble earths 0·3 (Kirkby. Quart. Journ. Geol. Soc., London, 1861, p. 3231.)

The character of this group in South Yorkshire has lately been more accurately described by Mr. J. W. Kirkby.‡ To judge from fragments examined by me, the upper magnesian limestone of the neighbourhood of Doncaster consists partly of yellowish-grey laminated dolomite or stinkstone, partly of thin reddish and

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* The author has brought to the Geological Museum of Dresden a series of these concretions from Fulwell Hill, to which place Mr. Kirkby had the goodness to conduct him.

† Notwithstanding the lithological resemblance of the limestone here noticed, their geological position is undoubtedly somewhat different. The Hartlepool beds form the top of the upper limestone in Durham, and have always been considered to be the exact equivalent of the yellow and oolitic limestone of Roker Cliffs. They thus form the highest *well authenticated* strata in the Permian series of that county. The Marsden limestone, on the other hand, lies at the base of the same sub-division, having between it and the Hartlepool beds, the whole of the botryoidal and crystalline limestone of Fulwell and other localities, which has an aggregate thickness of more than 100 feet.—J.W.K.

‡ Quarterly Journal of the Geological Society of London, 1861, p. 287.

greenish calcareous shale, with *Schizodus obscurus* Sow, *Aucella Hausmanni* Goldf., and an alga, which, from Kirkby's description, may perhaps belong to the *Chondrites virgatus* Mün.

The underlying small-grained white dolomite, which is said to contain no fossils, and which (from the quarry of Roche Abbey), partly furnished building material for the new Houses of Parliament in London, is by Kirkby referred to the middle magnesian limestone. A white pisolitic limestone or dolomite, of Brodsworth, with *Acanthocladia anceps* and *Acanthocladia dubia* Schl., as well as other characteristic fossils of the middle group, is on the other hand described by him as the lower limestone of Pontefract, and arranged with the compact limestone. The *Terebratula elongata* Schl. is said to be the only brachiopod found in the magnesian limestone of South Yorkshire. The dolomite rests upon a friable sandstone of a small-grained globular structure, which again is lying on the red sandstone (lower bed), both of which are generally included in the lower red sandstone (Rothliegende) under the denomination of "lower red, yellow, and variegated sandstone of Pontefract."

The group of the upper magnesian limestone assumes its most characteristic appearance in the neighbourhood of Manchester, and other places in the north-west of England; and for our knowledge of it we are chiefly indebted to the elaborate researches of Mr. Edward W. Binney, of Manchester.* This formation, under the denomination by Binney of "red and variegated marls and limestones, or upper permian,"† consists chiefly of red and greenish

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* E. W. Binney, in Transactions of the Manchester Geological Society, vol. I., 1841; and in Memoirs of the Literary and Philosophical Society of Manchester, 1855, 1857, and 1861.

† I have always classed the red and variegated marls and limestones found at Newtown, Bedford, and other places near Manchester, with much lower beds in Derbyshire and Yorkshire, than those named by the author in the text, namely,

narls and shales, in which thin laminæ and nodules of a light grey and partly reddish dolomite limestone are embedded,* containing the usual fossils of the upper magnesian limestone, with the total exception, here also, of the *Brachiopoda*. These fossils have already, in 1841, been described and delineated by Capt. Brown†. They may, as already stated, be referred to the following genera:—

Trochus helicinus. Schl.; as *Turbo Mancuniensis*, and *Turbo minutus*. Brown, pl. 6, fig. 1, 5.

Rissoa (an *Turbonilla*) *Gibsoni*‡ Brown; *Rissoa pusilla*, *R. Leighi*, and *Gibsoni*. Brown, pl. 6, fig. 6, 11, and 15, 17.

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with the Fox beds at Bolsover, and some ribbon beds of limestone near Hooton Roberts. Their organic remains, and physical and chemical characters, in my opinion, bear great resemblance to those of the latter beds, although I am aware that Professor King and other able geologists are of the opinion above expressed by Dr. Geinitz. I call them "Upper Permian," it is true, but my "Lower Permian" comprises the Astley and Moira sandstones, which Mr. Howse would class as true coal-measures; and I myself, from the examination of their fossil plants, would also be inclined to do so, did not the strata contain quartz pebbles, and were quite unconformable to the underlying coal-measures. It is possible, however, that there may be an unconformable portion of the upper coal-measure.—E. W. B.

* The analysis of Prof. F. C. Calvert gave the following results:—

Marl beds of Astley.		68·00	Limestone beds of Astley.		16·06
Matter insoluble in acids	0·33		.....	1·00	
Soluble silica	7·00		.....	4·66	
Sesquioxide of iron	1·33		.....	2·66	
Alumina	18·00		.....	63·04	
Carbonate of lime	5·00		.....	10·33	
Carbonate of magnesia	0·34	32·00	and potash.	0·66	
Soda			Loss.....	0·69	83·0
		100·00			100·0

(Binney, l. c.,

† Trans. of the Manchester Geol. Soc., vol. 1., p. 63, pl. 6.

‡ We prefer the name "*Gibsoni*" to the name "*Leighi*," (both *simult*
given by Capt. Brown), because its pronunciation is easier to persons wh
conversant with the English language. Kirkby has lately combined bo
the name *R. Leighi*.

Turbo obtusus. Brown sp.; as *Rissoa obtusa*, and *Rissoa minutissima* Brown, pl. 6, fig. 12, 14, and 19, 21.

Natica minima. Brown, pl. 6, fig. 22, 24.

Gervillia antiqua, Mün., as *Avicula inflata*. *A. Binneyi*, and ***discors.*** Brown, pl. 6, fig. 25, 28.

Schizodus Schlotheimi, Gein., as *Axinus rotundatus, parvus, undatus,* ***pusillus***, and *Lucina minima*. Brown, pl. 6, fig. 28, 33.

Schizodus obscurus, Sow. Brown, pl. 6, fig. 18; and

Pleurophorus costatus. Brown, sp., as *Arca costata*. Brown, pl. 6, fig. 34, 35.

Mr. Binney, in whose instructive collection the originals of these are still preserved, was kind enough to conduct me to one of the chief localities for them, at Newtown, near Manchester. He has given an accurate section of all the beds observed by him there (l. c. 1855, p. 18).

The variegated sandstone appears in the strata overlying these calcareous beds, which rest upon a coarse dark brown ferruginous sand, with a few larger pebbles. This bed of sand has, according to Binney, a thickness of 1ft. 6in., and is followed by a red, finely laminated clay 2ft. thick, and lastly, a very thick bed of small-grained, mostly compact, red sandstone, with green stripes and spotted patches. According to Binney, this "the lower now red sandstone of Vauxhall" has a thickness of 320 feet.

The relative position of the upper magnesian limestone of Bedford, in Lancashire, is said to correspond very nearly with that at Manchester. Besides most of the above-mentioned fossils, it

also contains a scarce sea-sponge, the *Tragos Binneyi*, King. Good specimens of the genera *Schizodus obscurus*, *Aucella Hausmanni*, and *Gervillia antiqua*, which are common here, are found in the Borough Museum of Leeds, which is justly held in high estimation.

If I am not mistaken, Mr. Binney still considers the dark brown, coarse-grained sand, underlying the red marls, as an equivalent of a conglomerate formation, of sometimes considerably greater thickness, which is common in the neighbouring district, and which probably is corresponding with the "upper Rothliegende" of Germany. According to some of the sections of the coal-measures, given by him, its stratification is unconformable. (See also Binney, l. c. 1857, p. 6.) The said conglomerate formation, which is stated by Binney to be 12ft. 6in. thick at Seedley, near Manchester, 21ft. at Patricroft, 1½ miles from Seedley; and not less than 350 feet at Collyhurst,* would consequently, in the north-west of England, not only take the place of the lower and middle magnesian limestone, which never are found where the conglomerate exists, but also extend into the region of the upper magnesian limestone, from which it is there much less sharply divided than is generally the case in Germany.

In this district the dolomite limestone of the upper group frequently occurs in a succession of thin beds, alternating with deposits of red and variegated clay and marls. In the section at Astley, comprising 230ft. 6in., Mr. Binney distinguished 55 limestone beds so parted. Now, when it is taken into consideration that the character of the fossil remains, found in the said variegated deposits, necessarily leads to the conclusion that their formation must have been contemporaneous with that of the limestone, the

* The author has here mistaken the soft red sandstone of Collyhurst or Vauxhall for the conglomerate seen near that place. The conglomerate there is only 1ft. 6in. in thickness, but further northwards it certainly attains a thickness of upwards of 300 feet.—H. W. B.

fact of the alternations adverted to seems to indicate an oscillatory movement in this district between the *marine* formation of the upper magnesian limestone and the formation of the lower new red sandstone (upper Rothliegende), which latter probably, here also, has originally been of a *freshwater* character; and this circumstance appears to afford a new and strong proof of the dyadic nature of the "Permian."

In all cases where the variegated clays of the Upper Dyas or Upper Permian, and those of the Lower Trias or Upper New Red Sandstone are found in juxtaposition and actual contact, they appear, by the conformability of their stratification, to be intimately linked together; and it is a very great merit of Sir Roderick I. Murchison to have called attention to that fact, in explaining the characteristics of his Permian system.

Where again the upper limestone appears more independent and of the character of a pure marine formation, there is much less temptation to refer the variegated clays or red clay shales at the basis of the variegated sandstone, to the Dyas; as I have already, in these pages, proved, not only for Germany, but partly for Russia.

I must leave it to my esteemed fellow-geologists on the other side of the channel to decide, if this view may not be confirmed by similar facts also with regard to England, and will merely, in conclusion, again call attention to the following two cases:—

In Sedgwick's Section at Knottingley (Pl. 7, fig. 6) there is, in the uppermost strata of the magnesian limestone, at least an indication of an intrusion from the Trias of a bay-shaped deposit of red clay or marls.

In Binney's Section at Scedley, near Manchester, l. c. 1857, p. 51, are mentioned:—

Till	61ft. 6in.	—as Drift.
Soft red sandstone, with fine small rounded quartz-pebbles in it	139ft. 0in.	„ Trias.
Very tenacious red clay	8ft. 0in.	„ Permian.
Red marls and thin beds of limestone	121ft. 6in.	
Conglomerate	12ft. 6in.	
Coal formation with *Stigmaria ficoides*	30ft. 0in.	„ Carboniferous.

Here the question may be raised, if that very tenacious red clay referred by Binney to the Permian, may not be included in the Trias, which would bring the arrangement in perfect coincidence with the facts found in Germany and Russia.*

2. The middle magnesian limestone, the designations of which, in England, have already been noticed in the introduction, corresponds very closely with the "Rauchwacke" of Thuringia. It passes from crystalline and almost compact, mostly cellular dolomite, into fine earthy pulverulent strata; and its stratification is most frequently irregular and indistinct. At Humbleton Hill, near Sunderland, its prominent colour is snowy white; at Tunstall Hill, another famous locality for fossils of the magnesian limestone formation, it is a yellowish grey, with ocherous spots; and at other places, as at Clack's Heugh, on the river Wear, near Sunderland, it forms light yellow unstratified masses partly of a fine-grained sandy texture.

The dolomite of Humbleton Hill contains carbonate of lime 51·50, carbonate of magnesia 44·84, insoluble matter 1·60. (Thomson, Annals of Phil., vol. iv.)

The middle magnesian limestone forms, in England, the chief deposit of fossils of the magnesian limestone formation, and has

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*After going through the pebble beds of the trias, these red clays were reached. I classed them with the underlying marls containing *Schizodus obscurus* and *Bakevellia antiqua*, but it is possible that they may belong to the Trias, as Dr. Geinitz here suggests. The only line of demarcation which I have been able to draw between these two formations is the change from the pebble beds to the red clays. Although termed "clays" by the borers, I take them to be the upper part of the red and variegated marls containing limestones.—H. W. B.

therefore been called the shell limestone, a denomination which cannot be adopted in Germany, where the name "Muschel-kalk" has from time immemorial been given to the limestone of the trias. There are but few localities in Germany where the "Zechstein" can in this respect be compared with the middle magnesian limestone of England. The "Rauchwacke" of Posneck, above all other places in Germany, can, however, rival even the richest locality in England, Tunstall Hill; and the already (p. 220) described place at Rahnis, with regard also to the frequent occurrence of the *Productus horridus* and the *Spirifer alatus* in the there existing lowest beds of the Rauchwacke, presents in particular the greatest analogy to the above-mentioned localities near Sunderland.

Most of the genera from the lower and middle Zechstein, in Germany, are found together in the shell-limestone of England.

A breccia sometimes met with at the base of the middle magnesian limestone, and to which the conglomerate mentioned by Sedgwick, in his section at Bramham Moor (l. c. pl. 6, fig. 2, 3, 5), may perhaps belong, would, from its relative position, exactly correspond with the breccia described by Dr. Richter (p. 221), in his section of the country near Saalfeld.

3. The lower magnesian limestone, or compact limestone, is, just as in Germany, underlying the dolomitic middle magnesian limestone. I saw it myself well exposed in the vicinity of the Messrs. Hartley's extensive glass works near Sunderland. It consists there of a more or less regularly stratified, laminated, yellowish-grey, almost compact limestone, partly mottled with ochre. It is very poor in fossils, and the *Productus horridus* is only very rarely found in it.

A similar poverty in organic remains characterizes the limestone beds of the lower magnesian limestone group which are found at Clack's Heugh, embedded between layers of dolomite and marl-slate; but from the dolomite or middle magnesian limestone of the

same locality, Mr. Kirkby knows the *Nautilus Freieslebeni*, *Pleurotomaria antrina*, *Turbo helicinus*, *Arca striata*, *Gervillia antiqua*, *Terebratula elongata*, *Camarophoria Schlotheimi*, *Strophalosia excavater*, *Spirifer multiplicatus*, and *Fenestella retiformis*.

It is certainly very remarkable that the lower magnesian limestone in England is so bare of fossils, when it contains such an abundance of them in many places of Germany, although we certainly find exceptional cases there analogous in that respect to England.*

4. The bituminous marl-slate at the base of the lower magnesian limestone, or compact limestone, forms a thin bed, which is more or less grey from bitumen, and frequently mottled by iron-ochre, with yellow and dark brown patches. At Clack's Heugh it is only from 1 to 1½ft. thick, and contains a few scales of *Palæonisci*. At other places it has a much greater thickness (according to Kirkby 10ft.), and frequently contains the same or analogous fossils as the copper-slate of Thuringia and Hesse. Amongst the former the *Ullmannia selaginoides* Brongn, (*Caulorpa selaginoides*, King), and *Lingula Credneri*, Mün., are the most remarkable. The numerous fishes with angular scales, which occur in the magnesian limestone formation of England, and which have already been described, belong almost exclusively to this marl-slate. It is only very lately that a small species, probably belonging to *Palæoniscus*, has been

* The absence of fossils in the lower limestone is generally a noticable feature of that member in Durham. There are, however, as Dr. Geinitz observes, occasional exceptions even in that county, and more particularly in the southern part of it. At East Thickley, Summerhouse, Moorsley, and Whitley, fossils are not of very rare occurrence. Altogether, between thirty and forty species have been obtained from the lower limestone in Durham. In South Yorkshire the same limestone is more often fossiliferous; though this is due rather to the greater abundance of individuals, than to an increase in the distribution of species. It is indeed the lower limestone of that district that is comparatively speaking the fossiliferous members of the series.—J.W.K.

found also in the upper magnesian limestone, according to a communication from Mr. Kirkby, in a letter of the 5th October, 1861.

5. Incoherent Sand, or Friable Sandstone, underlying the marl-slate (yellow incoherent sandstone, Howse).—What is this bed of loose very fine sand, consisting of small globular grains of an uniform size, and yellow or brown colour, and this friable sandstone, on which the marl-slate rests, and which at the new pier of Tynemouth has a thickness of about 40 feet, but at Clack's Heugh nearly 100 feet?

In the first place, I think we cannot include it under the upper "Rothliegende," as it appears to follow from the elucidation given above (p. 173), that that formation ranges parallel with not only the lower, but, in some localities, also the middle and upper magnesian limestone, of which groups the former are developed at Tynemouth, as well as at Clack's Heugh. It cannot, therefore, notwithstanding the similarity between the two, be considered as an equivalent of the brown sand occurring at Newtown, near Manchester, which there occupies the place of the upper "Rothliegende." If it be at all considered as belonging to the Dyas or Permian, there appears to be no other alternative but to include it either in the lower "Rothliegende" or in the "Weiss-liegende" (Variegated Sandstone?). I have not been able to discover any analogy between it and the former, and would much rather be inclined to consider it as an equivalent of the "Weiss-liegende," that is, the sandy deposit with which the marine formation of the magnesian limestone (Zechstein) has commenced.

The question whether it belongs to the Permian (Dyas) or to the Carboniferous system, can only be decided by a continued careful investigation of its relative stratigraphical position. As for me, I am, for want of accurate data, not in the position to form an opinion. At Clack's Heugh it is conformable with the strata of

the superincumbent magnesian limestone; at Tynemouth, according to the sections drawn by Sedgwick, it is conformable not only with these, but also with those of the underlying red sandstone.

6. Lower Red Sandstone,—Sedgwick, Murchison, and others. Pontefract Sandstone,—Smith. — The above-mentioned yellow sand, or friable sandstone (yellow sandstone, incoherent sand), rests at Tynemouth and other places on a red or reddish sandstone, in which sometimes, as at Tynemouth, thin layers of red and green-spotted shale are embedded. In the latter are frequently found small fragments of the *Neuropteris gigantea*, Brongn, and *Sphenopteris latifolia*, Brongn, two genera which are amongst the most common in the coal-measures of England. The specimens of *Gyracanthus formosus* Ag. (Dyas 1. p. 24), described by King, another common fossil of the English coal-measures, is also, according to Howse, from these beds. After having, moreover, in the collection of Mr. Howse, seen several individuals of the *Calamites approximatus*, Schl. the *Cal. cannaeformis*, Schl. the *Trigonocarpon Parkinsoni*, Brongn, and a *Sigillaria* with small cicatrices from the basis of the leaf-stalk, all from the said locality, I cannot but give my adherence to the opinion of that esteemed friend, that the red sandstone in question, with embedded red and green-spotted shales belongs to the coal-measures. According to him, its stratification does not deviate from that of the normal coal-measures of the locality.

But, in again referring to the clear sections given by Sedgwick, we find that the stratification of the red sandstone is partly conformable (at Tynemouth and Kirkby coal pits, pl. 5, fig. 1, 2), and partly unconformable (pl. 5, fig. 3, between Eppleton, Hetton, and Ellemore) as well with the magnesian limestone formation as with the coal-measures. From the latter circumstance it may at least be concluded that the rocks already formed have suffered partial dislocation before the later formation had been deposited

on them. On the other hand, the sections at Brantham Moor pl. 6. also clearly show the stratification of the magnesian limestone to be conformable with the underlying red sandstone, in which the yellow incoherent sand and sandstone is included (lower red and yellow sandstone.)

Most authors have followed Sedgwick's opinion, and placed the lower red and yellow sandstone on a parallel with the true "Rothliegende" of Germany. This view is adopted in the maps referred to in the introduction; and even in his latest memoirs of 6th March, 1861, on the Permian formation in South Yorkshire, Kirkby considers the lower red and yellow sandstone of Tynemouth, Clack's Heugh, Hylton Castle, &c. in Durham, and the lower red, yellow, and variegated sandstone of Pontefract, Hickleton, Cadeby, &c. as equivalents of the "Rothliegende."*

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* The systematic position of the sandstones that are almost invariably found at the base of the magnesian limestone in Yorkshire, and below the marl slate in Durham, is not, it must be confessed, easily determined. The majority of English geologists continue to follow Sedgwick in classing them as the basal member of the Permian series, and as the equivalent, either wholly or in part, of the German Rothliegendes. But, as Dr. Geinitz here points out, objections have been raised against this classification by Mr. Howse, who considers these sandstones to more properly belong to the coal-measures. The grounds on which Mr. Howse bases this opinion are: first, the conformability of the lower red sandstone of Tynemouth and Cullercoats with the underlying coal-measures: second, the apparent general unconformability of that sandstone with the limestone above; third, the identity of lower red sandstone fossils with coal-measure species. Now it is possible that this geologist may be right in his views, and Sedgwick and other geologists wrong in theirs. But it appears to me, that before we abandon our old views on the subject, we should have before us the results of a more general examination of the geological relations of these hitherto Permian sandstones, in their range from Durham, through Yorkshire, into the Midland Counties, than Mr. Howse seems as yet to have made. For it may be that their conformability with the coal-measures at Tynemouth and Cullercoats is merely a local and exceptional occurrence. Professor Sedgwick, though he does not directly state, implies unconformability between them and the coal-measures in South Durham, where he represents the magnesian limestone, and hence along with it the lower red sandstone, dipping to the S.E., while the coal-measures dip to the N.W. We should not forget, also, that this authority distinctly describes the lower red sandstone of Yorkshire as consecutively overlapping the coal-measures and millstone grit, as it follows the contour of the magnesian limestone escarpment. The correctness of this has never been questioned. On the contrary, it has invariably been accepted by geologists, some of whom most undoubtedly have corroborated

In England, which has been in such a complete manner geographically explored, a comprehensive monograph on the productive coal-measures is still a desideratum. There are abundant materials for such a work, not only in the various memoirs of the highest merit published by English geologists, but also in the collections of many of the natural history museums of the country. When completed, it will give the best elucidation of this sand-

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it by personal examination. Now this fact proves, in my opinion, far more for unconformability than the Tynemouth and Cullercoats prove to the contrary. It appears to indicate the existence of a break between the coal-measures and the sandstones in question, which, though local in one sense, is yet apparently common to the north-east of England, and thus of far more value in its bearings on systematic geology than an occasional coincidence in dip. Besides this, supposing these red and incoherent sandstones were as a rule conformable to carboniferous strata, it would still remain to be shown that they were unconformable to the magnesian limestone. Until this could be shown, they would belong as much to the strata above as to the strata below. But their co-extension with the limestone escarpment, and invariable presence beneath the limestone in all sinkings and borings, establishes, I think, their conformability to the strata above. The strongest argument in favour of the carboniferous classification of these sandstones is to be derived from their fossils. Identity of fossil remains undoubtedly indicates close geological relations. And as it is not to be disputed that the lower red sandstone plants, found by Mr. Howse at South Shields and Tynemouth, have been correctly identified with carboniferous species, it can neither be denied that the geological relations of that sandstone with the carboniferous system are intimate. This we must admit. But still it does not follow that the sandstone should be given to the carboniferous system in consequence. For in viewing the question in this light, it should be borne in mind that the palæontological relations existing between the Carboniferous and Permian rocks are generally intimate; and that besides a striking similarity of generic types, there are several species of mollusca, entomostraca, and bryozoa, which occur in both groups. Hence, though the fact of the fossils of the lower red sandstone being the same as coal-measure species, is still of considerable importance, it yet has not that value which it would have possessed had other Permian species all been peculiar to their own formation.—J. W. K.

The following table shows the arrangement of the Permian strata of the north-east of England as indicated in the preceding notes. Excepting that it includes the lower red sandstone, the plan is essentially that which Mr. Howse proposed in 1857. It differs from the arrangement given by Professor King, in a tripartite instead of a quadripartite division of the limestone. According to that authority, the middle limestone of the accompanying table should be separated into two sub-divisions, named by him the fossiliferous, and the brecciated and pseudo-brecciated limestones. But it is considered by those who have more recently investigated these rocks that the fossiliferous and brecciated limestones of Professor King are merely different phases of the same member, and hence not by any means to be adopted as systematic sections of the series.—J. W. K.

Tabular View of the Permian Strata of the North-east of England.

SUB-DIVISIONS.	DURHAM.	SOUTH YORKSHIRE.
Hunter Schiefer.	*Red Sandstone* overlying the Magnesian Limestone in the S. E. part of the county?—(Howse.) Thickness,—50 ft.?	*Red Sandstone* and *Marl* near Doncaster and Tickhill—(Geol. Survey.) Thickness—50 ft. ?
Upper Limestone.	*Yellow* and *Oolitic Limestone* of Roker and Hartlepool; and *Botryoidal, Concretionary,* and *Crystalline Limestone* of Halfway House, Building Hill, Fulwell and Cleadon Hills, and coast from Whitburn to Marsden. Thickness—250 ft.	Brotherton Limestone of Brotherton, Knottingley, Womersley, Pickburn, Loversal, Wadworth, Tickhill, &c. Thickness—120 ft.
Middle Limestone.	*Shell Limestone* of Tunstall and Humbleton Hill, Ryhope, Dalton-le-Dale, Hylton Castle, Clack's Heugh, &c.; and *Concretionary* or *Pseudo-brecciated Limestone* of Galley's Gill, Tron Rocks, coast between Ryhope and Hawthorne Hive, &c. Thickness—150 ?	*Small-grained Dolomite* of Lound Hill, Vale of Went, Brodsworth, Cusworth, Levit Hagg, Warmsworth, Roche Abbey, &c. Thickness—200 ft.
Lower Limestone.	*Limestone* of Pallion, Millfield, Pensher, Newbottle, Houghton-le-Spring, Moorsley, Pittington, Sherburn, Ferry Hill, Summerhouse, &c. Thickness—200 ft.	*Limestone* of Pontefract, Emsall, Wentbridge, Hampole, Brodsworth, Barnsbro' Cliff, Cadeby, Conisborough, &c. Thickness—120 ft.
Marl Slate.	Marl Slate of Clack's Heugh, Down Hill, Midderidge, Ferry Hill, &c. Thickness—10 ft.	
Lower Red Sandstone.	Incoherent and Red Sandstone of Clack's Heugh, Hylton Castle, Tynemouth Cliff, Downs' Quarry, Sherburn, &c. Thickness—100 ft.	Red, Yellow, and Variegated Sandstones of Pontefract, Hickleton, Wentbridge, Cadeby, &c. Thickness—100 ft. ?
Total Thickness.	760 ft.	590 ft.

J.W.K.

Tabular View of the Permian Strata of the North-west of England, as seen at Shawk, west of Carlisle, Westhouse, south of Kirkby Lonsdale, and Manchester, in the descending order.

	Shawk.	*Westhouse.*	*Manchester.*
	FEET.	FEET.	FEET.
1. *Laminated and fine-grained red sandstones	300	not seen.	not seen.
2. Red and variegated marls containing sometimes, but not always, beds of limestone and gypsum, with fossil shells of the genera *Schizodus*, *Bakevellia*, &c.	150	traces of them seen.	300
3. Conglomerate	4	300	50
4. Lower new red sandstone, generally soft and incoherent	7	500	500
5. Red shaly clays	not seen.	250	not seen.
6. Astley pebble beds, containing common coal plants, but quite unconformable to the upper coal-measures, termed by me lower Permian.	not seen.	not seen.	60

H.W.B.

stone bed, in which, in some places, a part of the "Rothliegende," and perhaps also part of the "Weiss-liegende," appear at present to be included.

Through Mr. Binney we have become acquainted with the true "Rothliegende," and indeed of its upper portion, in the region of the lower red sandstone of this north-west of England. That accurate observer mentioned to me that the reddish-grey sandstone underlying it, and which is very similar to the lower red sandstone of the north-east of England, contains plants of the

*The first four strata of the above series, Professor Harkness, F.R.S., in a fine natural section seen at Hilton Beck, north of Brough, estimates to be of 3000 feet in thickness.—*Quarterly Journal of the Geological Society* for August, 1862.

coal-measures, and that it occupies even a lower position than certain limestones of the coal-measures, which are rich in ichthyolites.*

I have myself seen, from the *reddish* sandstone of Astley, near Manchester, *Calamites approximatus*, Schl., *Cal Suckowi*, Brongn.; from the *red* shales at Ardwick, near Manchester, *Sagenaria dichotoma* Sternb., *Calamites Suckowi* Brongn; *Sphenopteris irregularis* Sternb., *Sphen. coralloides* Gutb., *Dictyopteris neuropteroides* Gutb., *Cyatheites villosus*, Brongn; *Cyatheites oreopteroides*, Göpp.; *Alethopteris lonchitides* Sternb.; all true coal-plants.

The upper "Rothliegende" of these districts, as described by Mr. Binney (l. c.), contains chiefly fragments of quartz, but, however, also fragments of the older rocks occurring in the neighbourhood. He has traced it to great distances, and thinks that he has recognised it so far as in the vicinity of Ballochmoyle, in Ayrshire, Scotland,† where it contains fragments of a brown amygdoloid, which are strikingly similar to those of the trap ("Melaphyr,"), of the author. At the same time he has found in it red copper ore and malachite.

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* Now, in the statement that "the reddish grey sandstone underlying it (the true Rothliegende), and which is very similar to the lower red sandstone of the north-east of England, contains plants of the coal-measures," the learned author is quite correct; but when he proceeds to state "that it (the true Rothliegende) occupies even a lower position than certain limestones of the coal-measures which are rich in ichthyolites," the Author has misunderstood me by apparently confounding the ribbon beds of limestone in red marls lying above the pebbly beds at Astley with the upper carboniferous limestones at Ardwick, and then stating that such pebble beds occupy an inferior position to the latter. It is certain that the Astley pebble beds containing coal plants occupy a higher geological position than the red shales which the Doctor accurately states also contain true coal plants. How much higher it is impossible to say, as it is most probable there are higher carboniferous strata than those yet seen at Ardwick, and there may be Permian strata lower than those up to this time met with at Astley—at present we cannot tell. These Astley beds are unconformable to their underlying coal-measures, as well as their overlying Permian beds.—H. W. B.

† Binney, in Leorhard and Bronyn. Schole, 1857, p. 732, conporalsi; Murchison, Siluria, 1859, p. 351.

The author has not obtained any certain information as to the existence in England of a lower "Rothliegende," or in general of any lower division of the Dyas. From the observations previously made in these pages, it appears that the absence of the Hornstone Porphyry? ("Felsit porphyr" proper) just in those districts of England where the Permian system is developed, has a bearing upon this question. It is repeatedly remarked that the existence of most of the Porphyries (Felsit porphyre) are linked to the period of the Lower Dyas; and vice versa, that the formation of lower "Rothliegende" stands in close relation to that of the porphyries.

The existence in England of the lower "Rothliegende," which is so general in Germany, and there forms such an imposing bed, might perhaps most easily be traced in the neighbourhood of Kidderminster, in Shropshire. It is at least indicated by the presence, in a reddish sandstone of Alveley, of the *Walchia pinaformis*, Scbl., which I saw in the collection of Mr. G. E. Roberts, together with some less distinct fossils. The exhaustive collection of specimens from the upper portion of the coal-measures of Wribbenhall, near Kidderminster, made by Mr. Edward Baugh, of Bewdley, will no doubt greatly contribute to the more exact determination of the palæontological relations between the coal-measures and the Dyas in this district.

Through the kindness of Mr. Binney, I have been allowed to add the notes that bear my initials, to this translation of Dr. Geinitz's observations on the Permian geology of England.

J.W.K.

For fear the critical tenor of the notes which we have added to this translation of Dr. Geinitz's observations on the Permian Geology of England should lead to wrong impressions as to the opinion we hold on Dr. Geinitz's work as

a whole, let us here express our high estimation of its worth. As a contribution to Permian palæontology, it certainly exceeds in elaboration and in general value anything previously published. For many years Britian could lay claim to having produced, in Professor King's monograph, the most complete work on this subject,—so far, at least, as the animal fossils were concerned; but now Dr. Geinitz has fairly out-distanced us, and Saxony may rightly claim the honour of having furnished the grand book on Permian palæontology.

E.W.B.
J.W.K.

An unanimous vote of thanks was passed to Mr. Binney for his paper.

The President—Could you give us a clear line of division between the trias and permian? The subject puzzles many of us, I believe.

Mr. Binney—Any one who saw the red clays opened by Lord Derby, in Cheetham, at the time of the meetings of the British Association in Manchester, in 1861, would have seen that one apparently passes into the other, and that they are inclined at the same angle. It is very certain that the trias beds are difficult to distinguish from the permian. The only means of distinguishing them is their fossils. In the neighbourhood of Manchester the latter beds are full of fossils.

The President—In some of the recently published geological maps I see that they make the permian in the primary and the triassic in the secondary formation, whilst, to the eye, the rocks are so like each other that the ordinary observer cannot easily distinguish them.

Mr. Hull—In this immediate district the basement beds of the new red sandstone always contain pebbles, which you cannot

mistake. They are generally rounded pebbles of quartz, and if you find one you may be sure you have got into the new red sandstone.

The President—In connection with the red sandstone at Poynton, one of our members, the late Mr. Hadwin, intended to give us a paper upon the point. He told me they had a large number of accidents when sinking by alighting just at the junction of the coal-measures with the red sandstone. So great was the dislocation that the telegraphic company had to ask permission to be allowed to place the wires over ground, as it was impossible to work them otherwise.

Mr. Binney—It is very important that something should be known of these beds by persons who are about to sink shafts.

The President—Mr. Salter at the meeting of the British Association in Manchester, in 1861, was undoing a great deal of the geology which had been laid down for years, attributing to permian what before was called trias, and to trias what was previously considered as permian. I want to know how to get a good line of division.

Mr. Binney—The undoing to which the President refers has been going on for some time; but it is no easy matter to give a definite line of division.

The President—The next subject we have to bring before the meeting is the discussion upon Mr. Farrimond's paper upon the Edmond's Main Colliery Explosion, read at the last meeting.

Mr. Farrimond—The discussion of the paper which I read before the Society at its last meeting our worthy Secretaries have thought

of sufficient importance to be brought forward again. I believe this is the first time that the discussion of a subject has been so brought forward. It has hitherto always been opposed on the ground that some of the members would come armed with perhaps a great many of the blue books, published by the mining inspectors, particularly some of our young members, and the plan has therefore been objected to.

The President—We have, however, some precedents.

Mr. Farrimond—Still I have no objection at all to the discussion being continued, but would rather like it than otherwise. I have to complain, however, that I have never seen a proof of my paper, which has been sent to the members in our published proceedings. There are numerous mistakes in it, and it has been mutilated so as to make it completely different. I was shown the manuscript with certain parts scored, and asked if I had any objection to their being left out, I said I had not, but I would rather take them out of the proofs, as I had not time then to make the parts separated harmonize.—I never saw the proof. I find that 200 copies of the pamphlets have been printed; and I wish it to be noted that I am not responsible for the way the paper has been issued. There were two points which I thought of great importance to members when I read the account given of the accident. First, if a fire occurs in an under-ground colliery, will gases be evolved by it that will explode at an open light; and is it requisite that the furnace should be put out? Second, if an explosion does occur in a colliery, ought the colliers to make their way to the shaft through the after-damp, or ought they to remain in the fresh air till rescued? I think that these parties in Yorkshire have been studying the evidence given in reference to the Hetton Colliery explosion, and I believe they thought that the gases being evolved from the fire caused the Hetton explosion. I believe that is why they acted as they did, no doubt according to the best of their

judgment. But I think the result would have been different if some of our experienced mining engineers whom I see here had been concerned.

Mr. Atkinson—I wish to say that in printing this paper it was found impossible to get it out, with all its corrections, in time for this meeting, when the subject was decided to be discussed again; such a course having been proposed by Mr. Goodwin at the last meeting. Mr. Farrimond's paper went through the hands of several of our officers, and they thought that some portions of it had better be struck out. But these portions did not at all affect the real questions treated of in the paper. The printers had orders to strike off only so many copies as would be sufficient for the members previous to the resumption of the discussion at the present meeting, any slight alterations, which might be required, being left to be ascertained in the course of the discussion. Every member will therefore get a corrected edition. The portions omitted are of no great length, and not at all essential to the points required to be discussed. And as to the few mistakes complained of, they are mostly verbal, arising from the difficulty of making out the manuscript; there is not one of any importance.

Mr. J. Goodwin—Mr. Farrimond may have a just right to complain that the paper is mutilated. So have I. Now, it is not the paper we had read to us the other day; it does not raise the objections which were raised the other day; and it does not now lay down what the proprietors shall give to their managers. Nothing now is said of Mr. Farrimond raising so many million tons of coal without loss of life; and there are many other important matters which are entirely lost sight of. Consequently I have as much right to complain as he, inasmuch as the public may be led to suppose that I had no right to complain in the manner I did of his paper. He is wanting to justify himself upon the slight mistakes which have crept into his paper. He spoke of the mode of procedure,

and of descending into the shaft, in a manner that was very jarring on the ear. These things cannot be attributed to the Secretary. To come to the real points at issue, let us see whether Mr. Farrimond is justified in bringing a paper of this kind before this meeting at such an inopportune moment. There is another official enquiry promised. There is evidence that cannot be arrived at before that enquiry is brought to bear—before we can descend into the mine and examine the state of the stoppings. Mr. Farrimond makes the gratuitous assumption that all the stoppings were weakened and blown down, and that Mr. Madison was not justified in taking the course he did. He says these stoppings were built in an imperfect manner, but I say it is possible they may have been built very firmly, and that if Mr. Madison had taken the course Mr. Farrimond wanted him to take, it would have been suicidal to himself and all parties concerned. Mr. Farrimond has not, in page 97, given the distance between the two dipboards. He says, "Mr. Madison and party, without attempting to restore this crossing, or put a stopping in the level, which would have answered the same purpose, proceeded along the downbrow intake, and succeeded in getting about 120 yards down, and passing six stoppings, which are at intervals of 20 yards; four of them they found more or less blown down, one remaining good, and the last completely demolished; and upon Clegg, one of the party, going a little further down, he was lost sight of, the smoke being so dense. 'The atmosphere (said Mr. Madison) was so stifling and choking that it was impossible to get further. The gases were of such a nature as to indicate they proceeded from burning coal. It was similar to passing up a cupola shaft with a fire on. He would not certainly recommend that the ventilation should be restored, unless he wished to commit suicide and produce certain death.' Some of the party suggested it would be desirable to restore the ventilation. Mr. Madison pointed out if they restored the stoppings it would bring the air down to the furnace, and cause an explosion. Is it possible that

Mr. Madison could have used this expression to men who were looking upon him as their leader? Surely Mr. Madison had satisfied himself before he went down that the furnace was out, as Mr. Mitchell, jun. told him it was put out."—It is really a question of restoring the ventilation. Mr. Madison is here taunted with not doing his duty, but I will undertake to say he did his duty, and as much as anyone else could have done under the circumstances. Inasmuch as Mr. Madison is not here, and poor Lawton is dead, I think it incumbent upon me to see that their character is not villified. I have no interest in either of them, but I know I am fully justified in protesting against these remarks. The two dipboards were generating so much gas that 10,000 and odd feet of air could not keep clear the amount of fire-damp which was being given off. That would have accumulated and risen up the intake brow. This would have been brought upon the furnace or burning coal in the backbrow, which Mr. Madison evidently alludes to if the ventilation had been restored. Mr. Farrimond speaks of the injudicious step Mr. Madison took in ordering water to be thrown down the shaft. All who have had any connection with collieries will know that it was one of the best things to be done in order to procure a temporary ventilation. I have seen it tried on many occasions, and I do not know anything that will produce the same amount of ventilation under the same circumstances, and with so little trouble. In passing from that subject, I would remark that Mr. Farrimond also speaks of the viewer, and says, the conclusion he is forced to, is that Mr. Madison was a consulting-viewer, and that it was naturally to be expected that he, being on the spot, every assistance that could be rendered would be given, and that a gentleman like him could render a great deal. It so happened that he did not render the assistance Mr. Farrimond expected, and he is therefore disappointed. On the last page of his paper he says, "These persons would do well to secure the services of a consulting-viewer, to act between the resident-viewer and the underlooker;"

and a little further on he again says—"The consulting-viewer, though he may not visit the mine quite so often, yet possesses greater practical experience, from devoting his time solely to one object; and the chances are he will be more successful in guiding operations." Where, then, is the consistency in stating that Mr. Madison is a consulting-viewer, and that he has neglected his duties, as such, when he is upon the spot, and stating that all proprietors would do well to secure the services of such gentlemen. I ask, what is the use of having a consulting-viewer that cannot be there; and when he does come, he is not competent, from what Mr. Farrimond says, to direct operations?

Mr. Farrimond—Mr. Goodwin says that I said Mr. Madison was a consulting-viewer. I said Mr. Mitchell was the consulting-viewer, if there was one at all at that colliery. The other portion of Mr. Goodwin's remarks are complete nonsense and not worthy of a reply.

Mr. Horsfall, jun.—I should like to ask, is carbonic oxide an explosive gas?

Mr. Farrimond—Our president thinks so from a paper he read.

The President—We shall be very glad to hear any member give us his views on the question Mr. Farrimond has propounded to-day, as to whether an explosion is likely to take place from fire-damp, when there are also present gases evolved by the burning coal in the mine. Perhaps some gentleman who has had experience of fires in mines would give us the result of his experience. Mr. Goodwin, you have recently had a fire, and perhaps you can tell us whether the gases evolved were of an explosive nature, or whether a quantity of carbonic acid gas did so neutralize the effect of it as to make it non-explosive.

Mr. Goodwin—I have never seen a case where gases evolved have been explosive. As you say, we have recently had a great fire, and when I went down to see it first, there were 40 yards of surface all in a glow. I took the first step generally taken—shut off all the air, but it had no effect whatever. I then allowed the gases given off and flame to go up the chimney by the return air-course, it fortunately happened that we had a good supply of water close at hand and means of supplying it. We have a furnace at the bottom, and it goes up a chimney along with the smoke from the underground boiler furnace. Contrary to expectation, the carbonic acid in this case, if any was generated, did not fall to the lowest point. It did not affect the burning in the least.

Mr. Farrimond—Mr. Goodwin says that contrary to expectation the carbonic acid in this case, if any was generated, did not fall to the lowest point. This shows what Mr. Goodwin knows about gases.

Mr. Atkinson—It would be heated, and fly up on account of its decrease of density from expansion.

Mr. Goodwin—It would pass up with the other gases I presume.

The President—My experience on this point is that where the coal does give off fire-damp, and coal, &c. is on fire in the mine, the explosiveness of fire-damp seems to be somewhat diminished; but that fire-damp will still fire although there may be a fire burning in the mine near to it. I have heard the contrary opinion taken up by one of our members, who contended that it was impossible for gas to explode near to a fire in the mine. But I myself have seen cases where the gas has actually exploded. I have seen it near to the fire exploding in the lamp; and I have heard Mr. Henry Andrew, of Fairbottom Colliery, and others, describe seeing it in this way. But, at the same time, I do

not put down to explosions of gas all those outbursts that take place when the fire is shut off for the purpose of extinguishing them. It too often happens that either the pit top or the entrance to the place is shut off so effectually that no safety-valve is allowed for expansion, and the expansion of the air itself forces down or removes those stoppings which are put up for the purpose of excluding air. That is sometimes attributed to explosion which is, after all, but simple expansion and the pressure of fire-damp. We have irrefutable evidence and experience that fire-damp exists under the pressure of several atmospheres. No gentleman has given any answer to the other question, as to whether the colliers should remain in the mine. I would just remark that when a great explosion takes place in a mine no advice to the contrary would keep any man in his place when he sees a way out of the pit.

Mr. Goodwin—It is contrary to the first law of nature that anyone should voluntarily remain in a remote part of a mine after an explosion. My conviction is that even Mr. Farrimond would do the best he could to get to the shaft, should he ever happen to be in a mine when an explosion takes place.

The proceedings then terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 6.] VOL. IV. [Session 1862-63.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, March 31st.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

The President announced that the Council had elected five new members, viz: — Messrs. Thomas Ashworth, Cheadle; Thomas Baldwin, Bury; John Aitken, Bacup; Samuel Wrigley, Oldham; and Geo. Nesbitt, Manchester.

Mr. E. W. Binney (Vice-President) having taken the chair, called upon the President to read his paper on "The Coal Strata of Lancashire." The following paper was then read:—

ON THE COAL STRATA OF LANCASHIRE.

BY JOSEPH DICKINSON, F.G.S.

In the first volume of the Transactions of this Society there are papers on the Geology of Manchester and its vicinity, and on

the Geology of the Lancashire and Cheshire Coal Fields, by Mr. Binney. These papers were given about 24 years ago—somewhere about the year 1839; but although so many years have elapsed since they were written, I can testify to the accuracy which characterizes most of the information they contain. To a great extent the sections given in those papers have, upon later research, been found to be correct. In one or two instances, however, there are some corrections required. I should also say that besides these two papers there have been papers given by the late Mr. Peace, by Mr. Bailey and others, on particular portions of the coal-field, but of which there is no proper account in the Transactions of the Society. I purpose, therefore, to give an account of the whole subject, and, in doing so, to

"Tell not as new what everybody knows,"

but whilst fully acknowledging my authorities, to supply the required corrections, together with additional matter of my own, which I think will not prove uninteresting to the members of the Society.

As you are all probably aware, the base of this coal formation rests upon the mountain limestone, which is seen cropping out near Clitheroe; within no part of the area of the coal-field, however, are the lower measures so much exposed as to exhibit the limestone. It is covered by a very thick deposit of shales and grit, the thickness of which, I believe, has never yet been correctly ascertained. Nevertheless various estimates have been made on this point, which may be taken as sufficiently close approximations. It is not, however, my present intention to go minutely into this portion of the subject. Suffice it to say that the grits and shales are very thick, probably thicker than at any other part in England. I shall therefore at once proceed to the coal-field itself.

I have confined my notice to Lancashire, although it is well known that the coal-field on the eastern side extends into the adjoining county of Cheshire. I merely mention this that we may know the part which is comprised, and the point from which we are starting.

Let me, then, begin by saying that at the boundary between Lancashire and Cheshire the lowest workable coal-seams crop out at Mossley, near Stalybridge. They then skirt round near the eastern boundary of Lancashire, passing at certain places into Yorkshire (where sometimes, without having cropped out, they dip away again in the opposite direction, and become overlaid by the whole of the Yorkshire coal-field), through to Littleboro'; thence midway between Bacup and Todmorden, passing near the Portsmouth station on the railway between Todmorden and Burnley; then gradually curving a little to the west, including the Worsthorn quarries, and so on nearly to Colne; thence turning in a westerly and south-westerly direction, along Padiham Heights, through Simondstone and Read, where the crop becomes very steep, dipping almost at an angle of 45°; then, leaving Blackburn outside, they pass through Oswaldtwistle to Eccleshill, Over Darwen, across to Chorley, round by Welsh Whittle, Heskin, and thence to Latham Park and Blaguegate; then southward, keeping a little to the west of St. Helens. On the south side the coal strata are overlaid by the Red Rock, or New Red Sandstone, Permian, &c.

The line which I have thus given forms pretty nearly half a basin, and throughout the entire length the general inclination of the strata is inwards to a centre. I need scarcely add that the inclination or dip is very much varied by the different faults with which the basin is divided. It varies from nearly level, through various inclinations to an angle of 45°

The coal-measures included in this Lancashire field have been

divided into three series, namely—the lower, or Gannister; the middle, and the upper series. That division has hitherto been found convenient, and I propose to adhere to it now.

As a general rule, I may say that the lower, or Gannister series, contains some of the best coking coals. It also contains the finest flags and tile stones. Some of these flags and tile stones are situated above what is known as the Gannister, but some are also worked from below. They are for the most part worked by quarries; but the flags and tiles lying above the Gannister are also extensively mined by shafts at Over Darwen. It is in the lower or Gannister series also where the principal earth is produced for making firebricks. There are plenty of similar earths in the middle and upper series; but it would seem that those in the lower produce bricks which stand greater heat, and they are consequently those which are chiefly worked for the purpose of brick making. Like the coals of the lower series, those of the lower portion of the middle series are chiefly good coking coals; and at the top, or upper portion, swift or hot burning coals are produced. The coals of the upper series are nearly all hot swift burning coals. Cannel or Parrot coal is found in each of the three series, but the best is in the middle series.

The cleavage of the coals in all three series is for the most part vertical to the bedding of the coal, and is well defined. But in the lower portion of the middle series, commencing at about Hulton, with the seams above the Arley mine, a different description of cleavage sets in, dividing the coals into a rhomboid form, and which is in addition to the ordinary cleavage, or board of the coal, and that, as we get eastward, gradually rises into higher beds, until at Pendleton the appearance is to be met with as high as the mine known as the "Rams." The floors of almost all the coals consist of an earth sometimes soft, and sometimes hard. When soft, it is generally called the warren earth, and when hard, rock

warren. Or it is often called the seat, or floor earth. This earth generally contains a large quantity of the curly fossil, known as the stigmaria ficoides; and the earth is what is generally worked up into clay for making firebricks. Occasionally, however, earths suitable for making firebricks are found above as well as below the coal-seams. As might be expected, over such a large coal-field as this the names of the seams change in different localities. For the purpose, then, of having some datum line to refer to, I shall in my observations upon the lower series take the Gannister, which is a well known rock of a very hard description. This Gannister is almost as hard as flint, and is a rock which extends over a very extensive portion of the coal-field, but not by any means over the whole of it. The principal portion in which it is found is about Oldham, Crompton, Littleboro', Smallbridge, Rochdale, and Chadwick Hall. It is an excellent datum line for this part of the coal-field; but in other portions it is not to be relied upon, as at some places, especially near Burnley, and at Over Darwen and Heath Charnock there is a rock occasionally met with so like Gannister that it is impossible to distinguish the one from the other. The true Gannister forms the floor of a coal-seam, which is known by a great variety of names, but to which for the sake of convenience I will add the arbitrary name of Gannister, by which it is occasionally known.

Commencing at Mossley, near Ashton-under-Lyne, the following section of the lowest coals is met with:—

	Yds.	Ft.	In.
Sandstone	—	—	—
COAL	0	1	5
Floor Earth	0	0	8
Shale and Sandstone	29	2	4
Shale	0	2	0
COAL, Victoria	0	1	9
COAL and Bass	0	0	9

	Yds.	Ft.	In.
Earth	0	0	2
Sandstone	1	0	0
Shale	5	0	0
Sandstone	3	0	0
Shale	4	0	0
COAL	0	0	7

The lowest of these three coals lies at a distance of about 326 yards below the Gannister coal. The principal, or 1 foot 9 inch bed, is the one which is being worked at the Victoria colliery, at Mossley. The three seams retain their character southwards to Early Bank, in Cheshire; but northwards they do so for a short distance only, and, except in that immediate neighbourhood, I know of no place in Lancashire where coal-seams are so fully developed so low down in the coal-field. At many places one and sometimes two thin corresponding seams, generally of poor quality, are met with, but not three such as at Mossley. At Hartshead, on the hill west of Mossley, the Gannister coal, there called the mountain or three-quarter mine, is being worked.

A general section of the principal coal-seams of the lower series near Hartshead is as follows:—

	Yds.	Ft.	In.
COAL (40-yards mine)	0	1	6
Strata, with an inch of *Coal*	34	0	0
COAL, upper foot	0	1	0
Strata	15	0	0
COAL mountain, or ¾ (Gannister)	0	1	10
Strata	10	0	0
COAL, lower foot	0	0	6
Strata	90	0	0
COAL, yard (sand rock)	0	0	6
Strata, about	180	0	0

And then the upper, or one foot five inch coal, given on the preceding section, at Mossley.

At Crompton, near Oldham, the lower foot coal is called the half

yard mine, and the Gannister coal is still called the mountain mine. The upper foot and the 40-yards coal are also still known by the same names. The upper foot coal has there a large number of round nodules both in it and upon it, and also a very large number of fossils, generally *Goniatites* and *Avicula-pecten*.

At Bamford and Ashworth, the 40-yards coal still retains its name, and there is another coal, called the bassey mine, lying about 30 yards above it. The upper foot still retains its name; and the Gannister coal is still called the mountain mine. The lower foot mine also retains the same name. The sand-rock mine below also retains that name; but at Wolstenholme it is called the three-quarters mine, and there is a coal there about nine inches thick, which lies about twelve yards above the three-quarters mine.

At Birchinley, near Rochdale, the coals still retain the same names, and also at Dearnley and Cleggswood. Then, passing on through Whitworth and Wardle to Bacup, the 40-yards mine takes the name of the little or top, or half-yard mine. It is known there by all these names. The upper foot retains its name, and at that point there are only very few balls and fossils with it, but there are still some, and also with the Gannister mine below. At Whitworth, Wardle, &c. portions of the Gannister coal where it originally cropped out all round some of the hills, have been entirely worked out, and small workings are commenced on the lower foot mine, which is there less than a foot in thickness. The Gannister coal at Bacup is called the yard, or main coal. The lower foot and the sand rock mines still retaining their names.

Up to this point there is no difficulty whatever in following the order in which these coals lie. The strata follow each other with surprising regularity, seldom varying more than ten yards in thickness between the same coal-seams.

About a mile and a half to the north-east of Bacup one of the large faults passes in a north-westerly direction, causing some alteration, and at the opposite side of that the principal coal of the Gannister series is known at Cliviger and all round the northern part to Colne, as the mountain four feet, and it is there generally accompanied by an unusually large number of very fine specimens of Goniatites and other fossil remains. It has also a large number of round balls in it, together with a quantity of flattened nodules near the roof. Apparently this is either the upper foot seam which has become thickened, whilst the Gannister coal below has deteriorated into coal and bass, or the upper foot and the Gannister coals have become united.

At this point I may notice that in the neighbourhood of Bacup, where there are so few of these fossils and balls, or nodules met with, in and about this seam, there are in the quarries in the sandstone underlying the sand-rock coal, a large number of nodules, generally about as large as an orange, which lie in the middle of the solid rock. In the northern portion, to which I have referred, the 40-yards coal is generally known as the top bed. But at the Towneley colliery, where the top bed is being worked, it is in two beds, which have been named the cannel and black mines, and there is a thin coal which lies above, called the horse pasture seam.

Returning to the south-west side of the large fault, between Bacup and Cliviger, of which I have spoken, the Gannister coal, which was at Bacup four feet thick, becomes much thinner in a westerly direction; and it is the principal mine that is extensively worked in Rossendale and also at Baxenden and Dunkenhalgh Park. On the high ground south of Rossendale, that is the sand rock coal which is chiefly worked, and also at Pilsworth, near Bury.

At Over Darwen the Gannister coal is called the lower, 70 yards, or half-yard bed; and is now being extensively worked. The

principal seam above it is there known as the yard coal, which, together with the little coal above it, corresponds with the 40-yards seam. The yard seam has for many years been worked in that locality. It has been, in fact, the main bed worked there; but it is now nearly worked out, except in the deeper portions. The flag and tile-rock of Darwen lies about 40 yards above the yard coal. The strata, about 10 yards in thickness, which separate the little coal from the yard coal, at Darwen, gradually thin out in the direction of Hoddlesden. At the o'd Hoddlesden Colliery the two seams were found gradually approaching each other until they came so near as to be worked together; and now, where they are being worked, there is only a division of black earth between, the rock being entirely nipped out. They continue together as one seam for some distance, but ultimately they divide out again, and at Belthorn the upper part is called the half-yard, and the lower the little coal. At Brookside and Duckworth Hall they again lie together, and are called the poor Robin bed. At Chorley, and also at Heath Charnock, the corresponding coals are known as the little and the higher mountain. At many of those places this little coal has a rock floor, which has often been mistaken for the true Gannister. The same mistake has also occurred as to the same seam at the Towneley Colliery, where both the upper and lower portions have a rock floor.

In the neighbourhood of Upholland, and at Bispham, there are the upper, middle, and lower mountain mines; the middle one apparently corresponding with the 40-yards mine; and the lower one, with the Gannister. It is probable that these mines correspond in that way; but the distance is so very great between the places that it is uncertain to say whether that is a correct position or not.

The total thickness of the strata between the Gannister coal and the Arley mine, is at Oldham, about 300 yards. At Simpson Clough, it seems to be thinner than at any other point, being

only about 253 yards. At Duxbury it is about 274 yards from the Arley to the higher mountain (40-yards mine), or probably about 350 yards to the Gannister, but the Gannister has not yet been proved there. At Clayton, near Church, the distance is about 308 yards from the Arley to the Gannister. Adding to this the total thickness of strata in which coal seams are found below the Gannister, namely 326 yards, as shown at Mossley and Hartshead, gives a total thickness of about 625 yards of coal-bearing strata in the lower or Gannister series alone.

The middle series from the Arley mine to the Worsley four-feet is about 975 yards in thickness. The upper series, above the Worsley four-feet has been proved at Patricroft to a thickness of 390 yards, but this is not the whole of it, and including the measures at Clayton near Manchester it is about 550 yards in thickness, so far as at present discovered. The total thickness of coal-measures in the upper, middle, and lower series, to the lowest coal-seam, is therefore about 2,150 yards, exclusive of the grits and limestone shales below.

In the middle series there are a large number of seams, and the field is divided into so many divisions by main faults—the largest extending to a thousand yards of vertical displacement or throw—that I find a table of sections will give the best general view of the subject, and show some of the principal changes which take place. Where the seams of coal diverge from or approach to each other, it is frequently where there is a division of earth between, and not bass or coaly matter.—[*See annexed Table.*]

The part known as the Burnley coal-field is not a detached portion, as is sometimes supposed and laid down on maps, but is connected with the main field by the lower strata up to the Gannister coal. The southern boundary, of what may still for convenience be termed the Burnley coal-field, is a remarkable fault, which runs nearly due east and west instead of north-west,

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like nearly all the other principal faults. At the eastern end this fault crosses the valley between Calder Head and Holme. It then passes Thieveley, where it has been worked for lead ore. Then on to Burnt Hills, near Clawe Bridge, where lead ore has also been found in it, and also at Cupola, a name derived from the furnace formerly used for smelting the ore which was then worked. The fault then continues westwards through the town of Church to the south side of the village of Rishton. For the most part of its course it consists of two faults, which are sometimes near together and sometimes run from 500 to 700 yards apart. The northern one is a downthrow to the south of about 70 yards, and the southern one a downthrow to the north of about 250 yards, forming a trough or deep belt between. In some parts of this trough the Arley mine is found deposited. At the eastern end of the trough the Arley mine is extensively worked by the southern pits of Cliviger Colliery. Again, in the trough, about 800 yards north-west of Deerplay Moor turnpike, at the west side of the cross road leading to the Bull and Butcher Inn, a small patch of the Arley mine has been met with and worked. At Cupola, also in the trough, the Arley mine has been worked for many years. There, the northern fault runs through the summit of Hameldon Hill, 1,342 feet above the sea. At that point, on the north side also of the northern fault, the Arley mine caps the high land of the summit of Hameldon Hill. It is the only point where the Arley mine is known to touch this fault at the north side. The southern fault has the lower strata up to the Gannister coal, abutting against its southern side throughout almost its entire length; whilst the northern fault has for the most part the Gannister coal abutting against its north side at a considerable depth from the surface. The two faults taken together may be looked upon as a great anticlinal division. The strata on the south side dip for the most part at a slight angle southwards into the main coal-field; and on the north side they dip to the north, forming the Burnley coal-field.

The contour of the Burnley coal field forms nearly half a basin. The north-western outcrop is very steep, the dip being nearly at an angle of 45°, and is called the "rearers." Like other parts of the Lancashire coal-field, the Burnley basin is divided by large faults, most of which have a direction 35° west of true north. By these faults it is divided into six separate main divisions, in each of which the Arley four-feet coal has been found near the centre. In the western, or Clayton (Clayton, near Church) basin the Arley coal has been extensively worked, the deepest point being about 60 yards, and very little of it now remains except a few pillars. The Gannister coal here lies about 308 yards below the Arley. On the south side of this basin the Gannister coal does not crop out, but at Dunkengalgh Park Colliery it bassets under the surface against the fault which forms the southern boundary.

In the next, or Altham basin, the Arley coal has been worked to about 90 yards deep, and most of it has been worked out; but the lower, or Gannister series, remains unworked.

In the third, or Hapton basin, a large portion of the Arley coal has been got, some to a depth of about 100 yards, leaving some still deeper, and the Arley coal is still being worked.

In the fourth, or Habergham basin, the Arley mine is being worked at a greater depth. At the south-eastern portion, at Hapton Valley, Burnt Hills, and Wholaw-nook, the Gannister series is also being worked.

In the fifth, or Burnley basin of the Burnley coal-field, the Arley mine extends over a large area. It is there where the greatest depth of strata in the Burnley basin are found. The deepest point is probably under St. Peter's church, in the town of Burnley, where the Arley mine will be about 320 yards deep.

The sixth, or last, is the Marsden basin, where the Arley mine is also worked. This basin extends to near Colne, where the mountain four-feet is now being worked.

The bedding of the strata in these six divisions of the Burnley coal-field is more laminated, or flaggy, than at most other parts of the Lancashire coal-field, excepting the lower or Gannister series, which is generally well bedded.

At Clayton and Bradford, on the east side of the city of Manchester, the coal strata are apparently surrounded by red rock, which disconnects the upper coal-seams from those at Pendleton and other places. On the north-west side of this patch the coal seams were formerly worked at the old St. George's Colliery to near the river Irk, where they were found to be cut off by the red rock. On approaching the red rock the uppermost seam of coal is cut off first, and so on in descending order, the lower seams extending further under. This indicates either that the red rock there fills a space where the seams of coal previously cropped out, or that there is a fault of a flatter description than usual, at which the coal strata are thrown down to the west. On the east side of the patch the red rock appears in a similar manner; but the inclination indicates that the coal strata are thrown down eastwards.

This part of the coal-field has long been considered as belonging to the upper series, and that it contains strata which are higher than have yet been discovered at any other part either of Lancashire or Cheshire. The principal seam of coal is supposed to be identical with the top, or Worsley four-feet. The appearance and quality of it, as well as the other coals, indicate that they belong to this higher series; but whether the principal seam, known as the four-feet, be identical with the Worsley, or top four-feet, is not yet sufficiently ascertained to be considered as beyond

doubtful. The four-feet seams at the two places resemble each other both in thickness and appearance, and in being swift burning and hot; also in having sometimes a trace of cannel coal on the top. But it is possible that the Clayton four-feet corresponds with some of the seams which lie above the Worsley four feet. The only other part of the section which these seams could be supposed to correspond with is some of the lower or Gannister series, which they do not resemble in the characters which I have named. The thin beds of limestone, known as the Ardwick limestones, which overlie the Clayton coal-seams, are conformably stratified with the coal-measures. They are considered to be coal-measure limestones, but are evidently far above the main bed of mountain or carboniferous limestone.

At Patricroft, and Bedford, near Leigh, thin limestones are also met with, but they are not stratified with the coal-measures, and are classed with red rock (Permian) strata, which here overlie the coal-measures.

As may naturally be supposed, I have been indebted to a large number of gentlemen, who have favoured me with sections for this paper. The principal of these donors, whom I beg heartily to thank, are—Messrs. E. W. Binney, F.R.S., F.G.S., John Hall, of Nangreaves; Jonathan Hall, of Baxenden; Andrew Knowles, Thos. Knowles, of Ince; Andrew Ray, George Peace, Jas. Oliver, Josiah Evans, James Darlington, John Mercer, George Gilroy, Robert Daglish, Sen., R. Fletcher, M.A., John Smith, Wm. Seddon, John Garside, William Bryham, Henry Jackson, Peter Pickup, J. Wilson, William Cardwell, Geo. Wild, Wm. Greener, Joseph Goodwin, William Waddington, and John Knowles. Also, the late Wm. Peace, John Daglish, John Evans, and Wm. Hibbert. Although I am much indebted to these and possibly to some other gentlemen, whose names I may have omitted, I have also in many instances supplied sections from my own personal observations.

I may further add, that in each instance I can corroborate the general correctness of the sections which have been supplied to me.

On the motion of Mr. Atkinson (Hon. Sec.), seconded by Mr. George Charlton, a vote of thanks was unanimously awarded to the President for his contribution.

Mr. Binney—We must all feel exceedingly obliged to our President for his very elaborate paper, although, I must say, I am afraid he has given us rather too much of a mouthful to digest at once. If we had had the lower, middle, and upper, at three different meetings, they would have formed three good papers for discussion. Our President in this paper has put the labours of many years together; and he has cordially acknowledged all his assistance from other gentlemen. Some years ago I read a paper to this Society on this subject. But we did not then print our papers, and it appeared in the *Colliery Guardian*, which I think Mr. Dickinson has not had the advantage of seeing. A great many of the points which Mr. Dickinson has brought before us I can quite confirm from my own experience. The lower coal-field is pretty well known ground; but when our President gets into the middle coal-field he has a most laborious and difficult thing to do in the identification of the seams. I must say I should like him to have gone a little into the higher coal-fields, and carried his identity of seams into the Oldham and Ashton districts. The four-feet at Pendleton and Worsley, and that of Bradford, would form a capital subject for discussion as to their identity.

The President—There are numerous sections here of the upper, middle, and lower coal-field, a copy of some of which I propose giving to the Society in the form of six side by side sections.

Mr. Thomas Ashworth—This meeting, and the public at large, can never comprehend a hundredth part of the trouble, and labour, and personal anxiety and care which Mr. Dickinson has had in the simple collection of this immensely valuable number of sections, which have from first to last cost hundreds of thousands of pounds to those individuals from whom he has obtained them. Nationally, and to the community at large, these sections, as collected by the President, are most invaluable. Sitting as we do here, and listening to the very expressive and concise manner in which Mr. Dickinson lays down his information, we can hardly judge of its worth. This may be very uninteresting to those who do not understand the subject, but it is incalculably important to those who are connected with the business of mining.

Mr, James Heywood—When these are printed in our Transactions, I wish Mr. Dickinson could favour us with a junction of them. I have never seen any series of sections of the Lancashire coal-fields so continuous, and so well brought together, as Mr. Dickinson has shewn us to-day. We have had a great number of separate sections heretofore; but the great merit of this paper is that the sections are continued from one part of the county to another, to show that the same mines appear again and again at several miles distance. We have here the materials of a very excellent horizontal section. As it is at present, some of us who have worked in and studied these matters understand it; but it will be extremely difficult for the general public to understand its meaning. The only way in my opinion will be to continue it one step further, and put the two side by side. It will be better far that there should now and then be a slight inaccuracy than that we should not have a general idea of the whole of the beds.

Mr. T. Livesey—Mr. Peace made a series of the most valuable calculations I have ever seen. He produced them while giving evidence in the House of Commons; and in them he showed that

along a line of railway from Bolton to Liverpool, and within the narrow space of three miles, a sufficient quantity of coal was contained to last, at the present rate of supply from that district, for 1,200 years.

Mr. Binney—Well, I don't know about that, nor do I pretend to guess how long our coal-fields will last. But I do know how plentiful coal was to be leased in the neighbourhood of Wigan twenty-five years ago, and I know also that it is difficult to get it there now.

Mr. Chatwood—I did not quite understand whether Mr. Dickinson thought that the Dogshaw and Arley mines were identical.

The President—That is a point upon which doubt exists, and I have been purposely cautious in dealing with the fact referring to it.

Mr. Binney—I believe myself they are identical, and Mr. Hall the other day told me he could prove that they are.

Mr. J. Heywood—I am thoroughly convinced of the great value of the section drawn up by our President, and I should be most happy to subscribe towards its publication. It would be of immense service.

The President—If anything were published, I think it should be the six vertical sections, running side by side, and not the longitudinal section extending from Rainford to Oldham, which I have made and exhibited to you.

Mr. Hull—Her Majesty's Government will publish sections similar to those which Mr. Dickinson has drawn up with so much care, and which reflect the highest credit upon his industry and skill. I have just had the pleasure of drawing out for the inspec-

tion of our Director some horizontal sections of the Lancashire coal-fields; and as they will be published by the Geological Survey, and will be drawn across districts where the structure of the whole series, from the "red rocks" down to the millstone grit, will be shewn to the greatest advantage, I think they will fully illustrate the coal-field. Of course I do not wish to do anything that will hinder the publication of Mr. Dickinson's section, but I say that these others to which I referred will be published in due course, and may perhaps answer all the purposes which Mr. Dickinson intends. I have listened with great interest to this paper, but of course do not agree with some of its points, One thing which I object to is the classification as coal-measures of a large portion of the district north of the main coal-field, which would produce a junction on a geological chart of the Burnley coal-field with the main coal-field. I certainly maintain that the Burnley field is detached from the main coal-field by a considerable tract of lower coal-measures, and millstone grit. I was extremely pleased to listen to the facility with which Mr. Dickinson recognised the various measures in different parts of the coal-field. But for my own part, I cannot help thinking that, with the exception of the Gannister coal, and the Arley four-feet mine, it is hard to attempt to put exactly in their proper position with regard to each other the seams of the middle series. There appears to be, at two parts of the field, a sudden and remarkable change in the coal-seams of the middle series, between Wigan and St. Helens in the one direction, and along the valley of the Irwell in the other. It is extremely difficult to cross those divided districts, and say that, with the exception of those I have just named, any seams which are found on the one side are the same as on the other. I would suggest that before the paper is published Mr. Dickinson will be kind enough to define Permian and new red sandstone, for there is a decided difference between them. I would suggest that the term Permian sandstone should be applied to that rock at Collyhurst, where the seams are broken off by a fault.

The paper is an extremely valuable one, and it is a great satisfaction to all interested in the advancement of science to see that the feeling of restraint which used to be so general when information was applied for, for fear that you were giving your neighbour some advantage over you if you made him as wise as yourself, is gradually being broken down, and that almost all colliery proprietors and managers are willing to give, for the good of the public, information which they have obtained at so great labour and expense.

The President—I do not think Mr. Hull has directed his attention to the Burnley coal-field, or he would be as satisfied as I am that it is connected with the main coal-field as I have described. The positions which I have given to the middle series with regard to each other will also, I believe, be found correct. I have avoided going into the divisions of the Permian and new red sandstone, preferring for a practical paper like this the term the miners know them by, "red rock."

Mr. Binney—I think there is no doubt about the connection of the Burnley coal-field with the main one. We are all much indebted to Mr. Dickinson for bringing before us an attempt to identify these middle coal-fields. I always shrunk from it myself. I introduced it once at these meetings, but the Oldham men on the one side, and the Wigan people on the other, could not come within 200 yards of identifying every particular seam. As to what the President has said with regard to the Pemberton four-feet and seven-feet, Mr. Bailey proved that the Edge Green seven-feet was the Pemberton four-feet. With regard to these red measures, in which I take a considerable amount of interest, Mr. Dickinson did not attempt to poach on my manor. The question of the four-feet at Worsley and Bradford would be a very excellent subject for future discussion. I have always thought they were the same, and Mr. Heywood and Mr. Looney

were of the same opinion. But there was never much evidence to go upon. The only evidence I ever got was at the Patricroft sinking, where we found 420 yards of strata above the Worsley four-feet. We managed, however, to get upon a red band of ironstone, and that is the only means by which anything definite can be arrived at as to identifying the two seams. In Beswick, just below the old Brewery, there is the same ironstone 420 yards above the four-feet, and 200 yards of red shales and grits containing limestones. There is no doubt, I think, of the ironstones at Patricroft and Beswick being the same.

Mr. J. Goodwin—I find Mr. Dickinson's section of the middle series of mines agrees with mine within ten yards—a section, by the way, which I have been at considerable trouble to prepare. Mine is 1,110, and his 1,100. In the bottom series I have also 275 yards, which has been obtained from the Redacre Woodley mines. With regard to the upper series of mines, my impression is that we have something there above what we have in any other part of the Lancashire coal-field. The two shafts sunk by Mr. Higson near the Denton toll-bar are about 1075 yards from the supposed outcrop of the uppermost mine in the middle series, equal to about 454 yards of sinking. Whether they were the upper series of mines or not that he met with we cannot positively say, but I should certainly think they were. His view was that he was sinking for these mines, and he is as likely to know as any one with whom I am acquainted. We have no evidence at all to prove that we are not at the upper series at Clayton.

Mr. G. Charlton—Does the President find any indications of the Lancashire coal beds rising up again in North Wales, or does the character of the North Wales coal beds bear any resemblance to those in the Lancashire coal-field?

The President—Generally. At Upholland the Gannister series of

coals crop out. Then on the western side of the hill, by means of a large fault of about 800 yards throw, the upper series is thrown in again, and have taken a dip in a direction towards Liverpool, where they become overlaid with the red sandstone, and coal beds ultimately appear again at Neston, on the side of the river Dee, and are apparently connected with those in North Wales, where the mountain limestone crops out from underneath. That is the main feature that is in the case. Whether these beds are identical or not, it is impossible for me to say, the connection is so very remote.

Mr. Binney—The lower field is seen beyond Hawarden. I have seen them there myself and found the *Aviculopectens* and *Goniatites* associated with them.

Mr. George Charlton—As a Society we ought to make an effort that this longitudinal section should be printed, either at the expense of the Society or by a subscription amongst the members. I believe very many gentlemen have been waiting for years for the sort of bird's eye view which has been so ably put before us to-day by our President. I beg, therefore, to move—"That the council of the Society do take into their consideration the desirability of publishing Mr. Dickinson's sections."

Mr. J. Heywood—I very gladly second the motion.

The President—I should like to repeat that if anything were lithographed those six sections I spoke of would be the best working sections.

The motion was put to the meeting by the chairman, and unanimously carried.

ON SOME TEETH AND A FLINT FOUND IN THE DRIFT AT BARROWFORD, NEAR BURNLEY.

BY J. WHITAKER.

No doubt the neighbourhood of Burnley is capable of yielding materials for an interesting paper on the drift; but as a sufficient number of facts have not been collected to warrant a general and detailed statement, I shall, on the present occasion, confine myself to a brief account of the superficial deposits in which the fossils under notice (two teeth and a flint) were found.

They were met with on the banks of one of the principal tributaries of the Calder, about five miles to the north of Burnley. This tributary, from its source on Pendle Hill to the place where the fossils were found, flows through a rather confined valley, which, to a considerable height on both sides, is occupied by the boulder clay, which here assumes the form of a stiff blue clay, interspersed with highly polished and rounded boulders, principally of limestone and millstone grit. Many of the boulders, on being taken from the clay, exhibit striations and scratchings, as if they had been subject, at some period of their history, to the action of ice.

In the wider parts of the valley the above-named clay is covered by three or four yards of gravel, on the top of which lies sand about two feet thick, which is finally covered by three feet of fine sandy soil, the whole resting on the millstone grit series of rocks; so that a complete section would show—

1	Sandy soil	3 feet.
2	Sand	2 „
3	Gravel, in which the teeth were found.....	14 „
4	Boulder clay, the thickness unknown.	

The teeth were found during the cutting of a trench across the

widest part of the valley, and were embedded in the gravel, six feet below the surface. They evidently belong to the genus *Equus*, but whether to *Equus fossilis* or not I have not yet been able to ascertain. The flint I picked out from amongst the materials that had been thrown out of the trench; so that I am unable to state its exact position in the drift.

With the limited knowledge that I possess of the relics of what is called the "Stone Period" in the history of mankind, I feel that it would be presumptuous on my part to offer an opinion as to whether the specimen under notice is a veritable flint implement or not; but I may, perhaps, venture to suggest that it so far resembles, in its general appearance, some flints that have been pronounced to be, and undoubtedly are, works of art, as to entitle it to be considered one of them. Nevertheless, whether it has been intentionally chipped into its present form, or is merely the result of accident, I shall leave for those who are better acquainted with the subject than I am to determine.

The thanks of the Society were given to Mr. Whitaker for his paper.

Mr. Heywood—There is one little doubt in my mind about the flint. It looks as if it were a good deal worn.

Mr. Binney—You must recollect that it came from a country where there are no flints.

Mr. Heywood—Just so. It seems to me to be an imported thing. It no doubt came from some distant locality.

Mr. Binney—I should like some gentleman who has investigated

flint implements of all ages to see these, and give us his opinion about them. It is the first we have seen of this kind; and I think the enquiry is worth pursuing.

Mr. John Taylor, jun., presented to the Society a couple of flints, which he said he found in the gravel drift about four miles from Crewe. One of them bore marks of having been chipped; and both were taken ten feet from the surface of the section. It was in a place where a pit had been opened by Lord Crewe for the purpose of procuring gravel.

Thanks having been given to Mr. Taylor for his specimens, and to Mr. Binney for his services as chairman, the proceedings closed.

advantages which the Society affords, I now lay before you a short description of that portion of it with which I have become most acquainted during my residence in the district; in doing which I have been actuated by a desire to assist, as far as I am able, both the practical worker and the scientific enquirer; and for the present shall confine myself chiefly to practical observations, leaving a fair share of the speculative to others more competent.

Fulledge Colliery is situate nearly in the centre of the trough or basin formed by the great east and west upthrows or faults between which the town of Burnley is almost entirely situated. Their general line of direction is from seven to eight degrees N.W. and S.E. magnetic, the strata dipping at an angle of about 2½ degrees, or 1 in 24, and its line of dip about 33 degrees N. of E., except in the immediate vicinity of the large faults. The fault on the east side (which seems to have bent the strata upwards for 20 or 30 yards along its western edge by the force of the upheaval, or by the holding on of the strata during subsidence) is an upthrow E. of from 90 to 100 yards, increasing northwards, and causing a change of dip on the E. side of it, while that on the W. keeps its usual dip, except in the case above-mentioned, until passing the Old Church, at which point a small basin is formed, probably by a bend in the fault, but soon reassumes its original dip, gradually increasing the displacement as it runs towards Pendle Forest in the direction of Danes House, or the N.E. of Pendle Hill, and decreasing southwards for the same reason in the dire[illegible]f the site of the old Roman Catholic chapel, and a little E[illegible]neley Hall. Stone House Fold is in the line of its dire[illegible]posing it to continue.

The fault on the [illegible]de is considerably [illegible] throw W. of about [illegible]rds, increasing [illegible] causing the angle [illegible]tion or dip [illegible] greater on the W. [illegible]he E. side.

upthrow to the S. of about 20 yards, striking the E. fault about Fulledge House, and (should it not cross the before-mentioned upthrows) diminishing them by the above distance; yet we find the large W. fault at Causeway-end, near the north end of the Towneley tunnel, where the Arley bassets or crops out in Whin Scar Clough, to have reached the thickness of 250 yards. Its line of direction can scarcely be parallel to the upthrow east, as it crosses near Lane Bridge, Causeway-end, Towneley Colliery drift, Birks House, and will probably run near to Stonehouse Fold, or Thieveley Scout, thus forming a junction with the other upthrow, and thinning out the Fulledge basin. It will doubtless diminish in a northerly direction, running nearly parallel (through and below the town for a short distance) with the general course of the river Calder, getting considerably less in the neighbourhood of Whittle Field, from the splitting off of several smaller ones, striking from it at various angles, as it cannot be near so large between Whittle Field and Parsonage collieries on the north side of Burnley.

In the Fulledge basin the first coal met with is the *Doghole*, at the depth of 19 yards from the surface. This coal is from five to six feet thick, of middling quality. The interstices in the cleavage and breakage being permeable to the water from the surface, are filled with fine mud or clay over a great portion of its extent. It has been worked out or left in pillars under most of the town: and what remains to be got lies on the north side of the Parsonage Colliery between the two large faults. It also caps a portion of Ill Park, but is nearly unworkable. The roof of the coal blue rag, or strong metal, containing fine specimens of *Lepidodendra* and a great variety of beautiful ferns: *Sillites*.

Kershaw [illegible] at the depth of 28 yards [illegible] the up[illegible] a hard heavy portion [illegible] inches th[illegible] from the lower [illegible]

thick of bing clod, or parting. The lower seam is middling in quality, and two feet thick, the lower half of which is a stone, or cubical splint coal. This bed is also worked out under the town where practicable, and what remains unworked lies in the deep end of the basin, between the rivers Brun, Calder, and Pendlewater, inside the large faults on the N.W. side of the town.

The Shell bed is next met with at a depth of 51 yards. This coal is also in two seams. The top, or upper seam, is eight inches thick, and separated from the lower one by a parting varying from four to ten inches thick. The lower seam is 28 inches thick, also worked under the town. The roof of this mine contains very fine specimens of fossil trees, similar to those found above the Doghole, but more numerous, four or five standing in the area of a ten feet diameter pit, and slightly leaning to the south. Of whatever substance the inner portion of the trunks was composed, it seems not to have decomposed until a deposit of at least eleven feet thick has taken place around the trunks, as I found them filled to their base with a similar substance to that forming the rock into which they protruded, or, if hollow trunks, they must have been thick and strong to either bear them up or preserve their original cylindrical form during the deposition of eleven feet thick of blue metal or clay shale, the bark or coal surrounding the casts being in some parts of it ¾ of an inch in thickness, and their base resting immediately on the top coal. The roof contains ferns, *Asterophyllites*, &c., and the coal is worked to about the same extent as the others above-mentioned.

The Thick bed, or Old Four-feet, is found at 56 yards. The greater portion of this seam is a dull looking bone or stone coal, of very good quality, being highly bituminous, and making a good house coal. The roof of this seam is a fine blue metal, abounding in *Asterophyllites*. This coal is worked out or left in pillars nearly the whole of its extent.

The Old Yard bed, or Maiden Mine, is the next met with. It is found at the depth of 67 yards, and is in two seams. The upper one is 6 inches thick, of middling quality, and separated from the lower one by a parting 20 inches thick, containing an almost endless variety of fossil plants, but being so crowded as not to leave many good impressions, except the large flattened trunks of *Sigillaria*, *Lepidodendra*, *Ulodendra*, &c. The lower coal is 34 inches thick, of poor quality, having a great many thin shaly partings in it. It has been worked to a limited extent, only about 20 acres having been got in the basin.

The Lower Yard bed is found at the depth of 127 yards. The strata between this seam and the Old Yard bed consists chiefly of dark shale and metal, containing two or three species of bivalve shells. There is a cannel 4 inches thick at 40, and a seam of inferior coal, 14 inches thick, at 53 yards. The Lower Yard bed consists of four thin seams of coal, in the following order:—Inferior coal, 6 inches; parting, 6 inches; inferior coal, 6 inches; brown stone, emitting a fœted odour when strnck, 18 inches; coal, containing large nodular pyrites, with vegetable nuclei, 13 inches; parting, 8 inches, and coal, 14 inches thick, the two lower seams only being workable. The roof of the uppermost 6 inches coal furnishes the fine specimens of *Anthracosia robusta*, for which this coal-field is remarkable. This bed has been worked at Fulledge Colliery, and near the Towneley tunnel, formerly known as Causeway-end, and Parkfield pits on its southern outcrop.

The Low Bottom, or Blindstone bed, is next met with, at the depth of 153 yards. It is 42 inches thick, with a dark brown pyritous band, locally termed "Blindstone," from one to two inches thick, lying near the roof, in some places splitting into two or three bands, in others thinning out altogether. This coal is bright and soft, and used principally as steam coal. In the shale forming the roof of this seam there is found a very large quantity of well

preserved fossil plants. Their variety is also very numerous. Whilst adhering to some of the flattened stems, we find the *Microconchus* and a specimen very much resembling a minute *Goniatite*, with the waved transverse striæ very distinct, and having a pyritous appearance. Immediately overlying the roof shale is a slaty strong dark shale, with thin brown bands of stone, and very thin layers of coal. This shale is separated from that below it by a rough conglomerate parting, about two inches thick, containing nodules of ironstone, smuts of coal, fossil plants, bones, scales and teeth of fishes, held together by a coprolitic cement. In the dark shale are found four or five species of shells, viz.:—*Anthracosia*, *Modiola*, *Orthonota*, *Cyprina*, and a small univalve. The out-crop of this coal on the south is in the Towneley railway tunnel; on the north-east, the precipice at Heysand-ford; on the other sides it will be thrown out abruptly by faults, with the exception of its outcrop at the western edge of Ighten-hill, near Gawthorpe. It has been worked out or left in pillars in the Fulledge estate, and is being worked at Whittle Field Colliery at present.

The Cannel bed, 30 inches thick, is met with nine yards below the Blindstone bed. The upper part of this seam is dull, heavy bastard cannel, while the middle is bright and light, getting rather heavy towards the bottom. On the top of this bed are found a large *Anthracosia* in abundance, with the valves mostly open, and crushed, and immediately below, in the cannel, remains of fishes—*Diplodus*, *Rhizodus*, *Megalichthys*, &c., and in the blue shale, a few feet below, are found *Anthracosia ovata*, very fine, and *Modiola*.

The Thin bed is found at the depth of 183 yards. This coal is 34 inches thick. At 12 inches from the top there is a thin band of shale varying from one inch to nothing but a parting in the coal. A band of black shale forming the roof of this seam has furnished a good collection of fossil fish remains, of which I have specimens, viz.;—Jaw and other head plates, teeth, scales, annular and other

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 7.] VOL. IV. [Session 1862-63.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, April 28th.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

The President announced that the Council (which had just met) had elected a new member, viz.:—Mr. John J. Atkinson, of Bowburn House, Durham.

The following paper was then read—

ON THE

FULLEDGE SECTION OF THE BURNLEY COAL FIELD;

BY MR. GEORGE WILD.

Feeling it incumbent on me, as a corresponding member of the Society, to contribute in proportion to my humble capabilities what little information I may possess from a few years' experience in the Burnley coal-field, and having by your kindness enjoyed the many

Colliery, about 15 or 16 feet above the coal. In the basin its outcrop south is near Old House, south of Towneley tunnel.

The Slaty Coal—a heavy, dull, inferior coal is found at 17 yards below the Great Mine. This seam is 20 inches thick, having a blue shale roof, with thin bands of ironstone, the shale scarcely darkening to a black on the top of the coal, yet containing two or three species of teeth and scales of fishes.

The Habergham China bed, or Cliviger Two-feet, will be found at the depth of from 260 to 270 yards. At the outcrop of this bed, at the foot of the precipice called "The Lowe," near Copy Colliery, Cliviger, it is nearly two feet thick, with a thin parting near the middle. It is inferior in quality, and has not been worked.

The Dandy bed is found behind the upthrow east in Fulledge meadow, at the depth of 190 yards from the surface, hence its position should be about 95 yards below the Great Mine in the basin; though from carefully noticing the ground bored through to the depth of 60 yards below the Great Mine, I am led to think the displacement of the strata by the above fault is greater as we descend, consequently it may be a few yards deeper than above stated to the Dandy bed. This coal varies from 20 to 30 inches in thickness. Occasionally patches of strong tough sandstone are found on the top, and protruding into it, diminishing its thickness and to some extent destroying or disturbing the cleavage, forming a great impediment to the working of it. The thinning of the coal under the patches of sandstone may be accounted for in two ways—first, by the action of the water, scooping out shallow basins subsequent to the matter forming the coal-bed being submerged (as such conditions are indispensable to the deposition of the sand in isolated patches, as we find it), and carrying away in the shape of mud the finely divided peat, or whatever substance it might have been, and depositing its heavier burden, the sand, in its place; for we find the upper portion of the seam wanting where the rock is thickest;—

secondly, or, the sand being deposited, as above-mentioned, would become hardened, and as fresh deposits were laid on, the pressure would become gradually greater, and the matter forming the coal being more readily yielding than the above deposit, would suffer depression. Should crystallization subsequently take place, it would always be subject, so long as deposition was going on above, to increasing pressure, which would partially account for the disturbance of the planes of cleavage. Coalpit House, in Cliviger; Rock Lane, Sep Clough, and Habergham Quarry, are a few of its outcrops.

The Arley Mine of Fulledge, the main bed of Burnley and its neighbourhood, is found at the depth of 240 yards from the surface, behind the upthrow east, and should be found at about 340 to 350 yards deep in the basin. If we make allowance for the greater displacement mentioned above, it may be a few yards deeper. Judging from the character of this coal, its general appearance and thickness, its position relative to the Bullion Coal, or Gannister seam—the nature of its roof generally—the fossil fish remains in it (a few seeming almost special to it)—and the remarkable series of regularly alternating blue shale and ironstone bands lying a short distance above it, I have no doubt it is the Royley of Oldham and Middleton (though generally much superior in quality), and the Arley of Wigan. This coal is 50 inches thick, and the upper half of it, with the exception of a few inches at the top, is a strong cubical bone, or stone-coal, giving off a very large quantity of gas (carburetted hydrogen), and is used chiefly for house-coal and locomotive steam purposes, making a hot, clean fire, and being a free burning coal. There is no distinct parting in the seam, yet the lower half is a soft, dull-looking dust coal, free from shale, but contains very much of what is locally named Rotten Coal or Lamp Black, from its soiling the fingers at the slightest touch, and having the appearance of decayed or burned timber. The upper half, or stone-coal, deteriorates in quality as we approach its

north-eastern outcrop, near Marsden Heights, at which place, and at Marsden, in some instances it is nothing but bastard cannel.

In the shale forming the roof of this coal, which is rather black, micaceous, and glistening, are found the remains of fossil fish in abundance, viz.: teeth, scales, rays, vertebræ, scapulæ, &c. of the commoner kinds usually met with, and a few species not common; also several nearly entire specimens of a new species of fish. This coal has several outcrops to the south, occasioned by the large faults and the anticlinal ridge or contortion of the strata, whose axes are probably near Crown Point, throwing out or bringing up the Arley in Whin Scar Clough, where it dips northwards, whilst it sets on again in Easden Wood, near Longshaw, where it dips south-west. It has also two southern outcrops in the Cliviger coal-field, one at Riddle Scouts and the other at High Bank Clough, and a noted basset in Sep Clough, on the west. Its southern outcrop in the basin is near Stonehouse-fold.

The distance from the Arley down to the Bullion Coal, so far as I am aware, is not known with any degree of certainty, having been variously stated at 450 and 688 feet. If, as has been stated, there be 500 feet of strata below the Arley, in which no coal occurs, the distance must be at least 800 feet on the N.E. edge of the coal-field at Townhouse, in the township of Marsden, as the top bed there has been worked at 300 feet above the Bullion coal. And probably the same bed has been worked at the Towneley old drift, though possibly the distance between the several beds overlying the above-named coal may be less in Hapton and in Burnley than at Townhouse. Whatever may be the exact distance, there are certainly two workable seams between them, the upper one being about 20 inches thick, and having a fire-clay shale roof, which is the seat of a very thin seam of coal a few feet above it. This coal is free-burning, and only middling in quality.

The Spa Clough top bed, probably being worked at Towneley

Colliery, is found about 50 yards before reaching the Bullion coal. It is very variable in thickness, and has a black stone or strong shale roof, containing remains of fossil fishes.

The next, and probably the lowest workable bed known in this neighbourhood is the Bullion coal. This coal is four feet thick, often containing a large quantity of rounded nodules, containing iron pyrites in the upper part of it, though I have seen it clear of balls in the same colliery when the top part of the seam was a mass of bastard cannel, coal, and pyritous greystone, mingled together, as is the case in the Bacup and Dulesgate district, where the coal is sometimes from five to six feet thick. It has been worked at Spa Clough, Burnt Hills, Dodbottom, Townhouse, and Carre Heyes. The roof of this coal is a dark blue lamellar shale, containing large rounded nodules of hard calcareous-looking ironstone, lying on the top of the coal, and often jutting into it. These nodules contain two or three species of the *Nantilus*, the *Goniatite*, and the *Orthoceratite*; also *Aviculopectens*; one of the nodules furnishing the remains of a large fish, along with very fine specimens of the tooth *Cladodus*. The shale surrounding the nodules is the *pecten* shale, and nearly all the species found in the nodules are found in the shale crushed flat. Occasionally there occurs on the top of the coal a thin layer of black bituminous shale. When such is the case, some very pretty shells and remains of fishes are found, viz.: *Buccinum*, *Pyramis*, or *Turritella*, two species; *Bellerophon*, two species; *Nucula*, *Solemya primeva*, *Posidonia*, and *Anthracosia*, jaws with teeth, and scales of fishes. A few feet above the coal, and lying on the *pecten* shale, is a stratum of light blue shale, varying from two to six feet thick, containing flattened elliptical and rounded nodules, often small, and enclosing *Coprolites*, which, when split open, disclose one or two species of very small *Goniatites*, *Orthoceratites*, and *Pisodoniæ*. *Goniatites Listeri* are also occasionally found in this shale; whilst some of the elongated nodules have furnished nearly

entire specimens of fishes. I think the *Crustacea* is not unrepresented, if a few of the specimens already collected were closely examined.

The thanks of the Society having been unanimously voted to Mr. Wild for his contribution, discussion was invited.

The President—The Society is, I am sure, very much indebted to Mr. Wild for giving us this description of the character and quality of the coals met with in the Fulledge Colliery, more especially as it is a colliery, as many of you are aware, which has recently been closed. Whether this is because the ground is becoming more valuable to build upon above than to work for coal beneath, I do not know. At any rate the colliery has ceased to be worked. Hence the placing on record of the information given in Mr. Wild's paper may be exceedingly useful hereafter, should some of the lower mines, which have not yet been reached by these pits, come to be worked. We have really no proper record kept of all the workings like this which have ceased to exist as active workings. Here we have a colliery, the deepest pit in the neighbourhood, closed up, and the lower workings are filled with water. Below, as Mr. Wild has told us, there still lie these mines — the Dandy bed and Arley bed — not yet been sunk through; and there is yet another pit at the bottom of the colliery which was commenced to be sunk down to these lower mines, but has been discontinued. All these are now filled with water; and unless any future worker of this ground could become possessed of the plans of these old workings, it will be a very difficult piece of work for him to carry on the workings. I do not know who will become possessed of the plans in this instance, or whether any at all will be kept. I have sometimes in similar cases to this found in one colliery office, where the owners have

been the original lessees of an adjoining colliery, all the plans complete; and amongst the old workings were pits filled with dead water. But of these plans the people who are now in possession of the colliery have no copy, and have been as it were groping in the dark, and boring continually for this dead water, not being able even to guess where it was. Should Mr. Wild have any plans of Fulledge Colliery, I hope he will deposit them with this Society, for I do not know of any better Record Office in the neighbourhood. In London we have the Mining Record Office, but that I apprehend is not intended to meet the wants of the extensive mining districts of the whole kingdom; in fact the building itself would not contain the fiftieth part of them. The objection I have named does not apply where water is kept regularly drained; but here is an instance of the deepest working in the locality filled with water in all the lower portions.

Mr. Wild, in answer to a question from one of the members, said that tubbing was commenced in each of the pits at about 72 or 73 yards from the surface. About 22 yards in each pit were tubbed. Since the works had been closed they had taken out eight feet of tubbing in each pit, leaving nearly 20 yards still there. There were some plans of the workings in the colliery office at Burnley.

Mr. Atkinson—I think it extremely desirable that a Record, as recommended, should be kept in a Society like this for the advantage of anyone who might require it hereafter. It is a dangerous thing for men to work adjoining old workings, of which they know nothing. Men may go on, and penetrate a place full of water, the result being that they are drowned, or immured in the pit. Some instances of this have occurred within my knowledge. There was a case at Clay Cross a few years ago, where the men worked up unconsciously to the old workings; the water suddenly rushed in, and a number of men and horses were drowned.

Mr. Wild said he should have no objection to furnish copies of the plans of Fulledge Colliery, if the owners did not object.

Mr. Farrimond said that owners generally had great objections to give to the public plans which it had cost them thousands of pounds to get. He said also that it was only fair that those who wanted information should pay for it.

Mr. Atkinson remarked that generally plans of old workings were thrown aside or mislaid; but if they were known to be deposited with a certain Society people would know where to apply for them, and would no doubt be glad enough to pay a reasonable sum for any advantage they might obtain.

Mr. Joseph Goodwin concurred in these remarks, and related an instance in his own personal experience, to show that the possession of plans of old collieries would have been of the greatest advantage to him, and that the giving up of such plans would not have been of the slightest disadvantage to the former owners.

Mr. Farrimond—The coal at Burnley seems to be the same as the coal at Wigan.

The President—It bears a striking resemblance to the Arley of Wigan. Some of the fishes on the roof of the Arley mine are exceedingly perfect. There are not only a very few scales, as some might think, but I saw one a few weeks ago as perfect as possible. The whole of the fish was there in an excellent state of preservation. It was a flat fish, and was taken from the roof of the Arley mine.

Mr. Knowles—I have observed remains that have had a few inches of cannel on the top of them, and they have been chiefly remarkable for the number of fossil shells lying perhaps several

feet above the mine. I wish to know whether Mr. Wild observed anything similar in connection with the Burnley coal-field.

Mr. Wild said there was only one bed where the shells lay on the top of the cannel, and that was over a mine of bastard cannel. It was chiefly with a view to the comparison of the Burnley coal-field with that of Oldham that he had entered into so many particulars in his paper. With a little labour he thought it was possible to compare three or four of the beds.

Mr. Richard H. Wynne—There is generally a bed of shells above the Arley mine at Wigan, which is a very good guide.

The President—Yes, but there are several beds, and you cannot take it as a guide to any particular seam. All that we know is that there is a particular bed overlying the Arley mine at Wigan, while there are other beds of shells found over other seams.

Mr. Goodwin said he had found shells similar in the middle of the bottom series, and in other places. He produced a shell taken from many hundred yards above the Arley mines.

The President—There is one point you named, Mr. Wild, that I should like to ask you about. It is of the connection of the Bullion or Mountain 4-feet seam with other districts. You said you considered it identical with the main coal of Bacup. Now, do you consider it identical with the upper foot coal, or Gannister coal of Crompton and Oldham?

Mr. Wild—It appears to me that both these beds must have got together.

The President—If you will trace these beds from Oldham right through to the Rochdale district there is no doubt that the

Mountain or Gannister coal of Oldham is the main bed of Bacup; and that the upper foot mine, which contains all these numerous fossil remains, at Oldham, is also the upper foot all through that district. Have you ever traced this through the Bacup district?

Mr. Wild—No, but I have seen it at Wholaw-nook, and there it partakes of the Holmes Chapel mine and the Bacup. The upper portion is a dull, bastard-looking coal, mixed with greystone, and is not fit to burn. I have seen it of the same character in the colliery at Carre Heyes. One portion of the mine I have noticed full of balls, while the portion 20 yards from it has been free from them altogether. I am not, however, well acquainted with the Bacup district.

Mr. Farrimond said he could not tell which of the three Mountain mines was the Gannister at Church.

Mr. Wild—There is a very good Gannister 40 or 50 yards above the Bullion coal, and there were several seams of Gannister in the neighbourhood.

The President said the principal bed at Church seemed to be the Gannister coal. A seam above, called Poor Robin, being the 40-yards coal.

The following paper was then read by Mr. Atkinson, the Hon. Sec., the author being absent:—

ON SINKING THROUGH DRIFT DEPOSITS;

BY MR. H. BRAMALL, OF RAINFORD.

In sinking for coal it is often necessary to pass through a considerable thickness of drift, consisting of alternating beds of

clay, marl, gravel, and sand, before the coal-measures are reached. If these are dry, the sinking through them is a matter of comparatively little difficulty; but such is rarely the case. They are usually more or less saturated with water; and then to carry a pit down to the "fast," as it is technically termed, is sometimes a most arduous undertaking. Instances are on record, and no doubt many will recur to the minds of those here present, where thousands of pounds have been expended in endeavouring to sink through such deposits without success. Mr. T. Y. Hall states the expense of sinking the Murton Pits to have been £400,000, incurred mainly in passing through a quicksand 34 feet thick, which there underlies the magnesian limestone. This is an extreme case; and I incline to think very many items of expense are included in this estimate which must have been incurred if the sand had not been there. Be this as it may, the same author states that the Haswell owners abandoned a pit after spending £60,000 from the same cause. I have endeavoured in the following paper to describe the methods commonly in use for sinking through alluvial deposits and quicksands.

If there is not much water to contend against the shaft may be temporarily secured either by timbering, as followed in the North of England, or by backcasing with bricks, which is the usual plan in Lancashire and the Midland Counties. In the first method, the whole strain is upon the curbs; in the second, each course of bricks should bear its own degree or share of pressure.

In carrying out the north country practice,* the usual course of procedure is to first mark out upon the ground a circle of the size of the pit, plus an allowance for the space to be occupied by the timbering and permanent walling. The earth is then dug out from this space to a depth of three or four feet, and a "crib," six

* A very highly-finished engraving, showing this system, will be found in Mr. G. C. Greenwell's "Mine Engineering."

inches square in section, is laid upon the bottom. A number of short deal boards are then placed behind this crib, reaching half way down its thickness and up to the surface, and touching each other at the edges so as to form a close lining round the pit. Another crib is then laid upon the former one, and being lifted up three feet above it, is there supported by short props resting upon the lower crib, and placed at intervals round the pit. Another length of ground, of, say six feet, is then dug out, and another crib laid at the bottom; backing deals are placed behind this crib, reaching from half way down its thickness to half way up the one above, and touching each other at the edges, are carried round the shaft as before. A crib is then again placed upon this last laid one, and raised half way up the backing deals, and there retained by props from the crib below; props being also placed between it and the crib above. After two or three lengths of backing deals have been thus placed, two balks are laid across the pit, upon the surface, and planks called stringing planks, six or eight inches wide, and three thick, are spiked to the balks and to the front of each ring, binding the whole together, and retaining the timbering in its place. The work is thus proceeded with until the stone head is reached. For easy dry ground this forms a very efficient temporary lining; and as in such ground most of the timber can be recovered when the walling is brought up, it is then also a very economical method.

In Lancashire it is more usual to "backcase" pits with a lining of dry bricks. A circle of rather more than 18 inches greater diameter than the outside diameter of the permanent bricking having been marked out, the earth is dug out, say five or six feet, and a wood bricking ring, nine inches wide by three thick, laid at the bottom. On this a wall of dry bricks, nine inches thick, is built round the shaft, and carried up to a level with the surface. The pit is then again sunk of a diameter corresponding with the inside diameter of the ring last laid, as far as is deemed consistent

with the safety of the men, such distance, of course, depending entirely upon the nature of the ground sunk through. A segment of the side of the pit is then stripped so as to permit a segment of another bricking ring to be laid perpendicularly below the one above, and this segment of the pit is then bricked up to the ring above, and wedged tightly up to it with wide circle wedges. An adjoining segment of the pit side is then stripped and another ring piece laid and bolted to the previous one, the brickwork on which is in like manner carried up to the ring above, and there secured by wedging. This is repeated until the whole ring has been laid, and the whole circumference of the pit cased with brickwork. Another piece of ground is then taken out below the last ring, and cased with brickwork as before, the whole process being repeated until the "fast" is reached. In order to derive the full benefit of this system of temporarily lining pits care should be taken, when putting in the last segment of the brickwork, to wedge every course tightly with wooden wedges, when, if the bricks are, as in all cases they ought to be, made to suit the circle of the shaft, every course will bear its own share of the thrust of the ground. It then becomes almost equal to permanent walling in point of strength. This backcasing is in all instances left in when the permanent walling of the shaft is brought up within it. Consequently, although superior to the north country system in point of strength, it certainly is in some degree more expensive.

It is very rarely that a case occurs in practice where any considerable thickness of cover exists that such cover is dry. Water in such cases is generally a more or less troublesome enemy to contend against. The clays and marls sometimes degenerate into loams, and are very wet, oozing out like mud from the sides of the pit, which are constantly on the move; the sands and gravels often become quicksands, yielding immense quantities of water. Such measures are sometimes termed "running" measures.

The methods usually adopted for passing through quicksands or other running measures are — first, sheet-piling; and second, running wood or metal drums. Though the arrangements necessary for carrying out these two systems differ so widely, yet the principle involved is the same in each, and is the very obvious one of affording support to the loose materials surrounding the shaft before proceeding to remove those inside of the same.

In the north of England this end is gained by a system of sheet-piling. I will not enter into any very lengthened description of this method further than is necessary to render the subject intelligible to those to whom the plan may be new, referring for further information to Mr. G. C. Greenwell's interesting account of the sinking of Framwell-gate Moor Pit, near Durham, contained in his "Mine Engineering," and to the excellent account in volume fifth of the Transactions of the North of England Institute of Mining Engineers of the Murton Winning, by Mr. Potter, where three pits were passed by this method through upwards of eleven yards of quicksand, lying underneath the magnesian limestone, in the face of the most formidable difficulties, and with the most complete success.*

The depth to the stone head is first ascertained by boring. If the piles it is purposed to use are 15 feet long, by six inches wide, and three inches thick, which is a very usual size, one may expect to get 12 feet of sinking out of each course of piling; and if the cribs are six inches square, each course of piles will lessen the diameter of the pit theoretically 18 inches, but usually in practice *a little more*. For every four yards of vertical depth of cover to be passed through in such a case, there must be an allowance of 18 inches *at least* in the diameter of the pit. If then the cover be, say 40 yards, and the pit when finished is required to be 13 feet 6

* For elaborate drawings of this system see Mr. Greenwell's work, and the paper by Mr. Potter.

inches diameter, *outside* the brickwork, the diameter to start the pit at the surface will be $\frac{40}{4} \times 1\frac{1}{2}$ feet + $18\frac{1}{2}$ feet = $28\frac{1}{2}$ feet. The pit is then commenced of this diameter, and carried if possible for a few yards in the manner previously described, with cribs and backing deals. A crib is then laid at the bottom of the pit, inside the last one laid, and so as to leave a space of three inches between the outside of the inner crib and the inside of the outer one. In this space piles made of spruce battens, 15 feet long, sharpened at the end, and, if the ground is strong, shod with iron, and hooped at the head to prevent them from splitting under the hammer, are driven three or four feet deep, touching each other at the sides, and being carried round the pit. A greater or less depth of ground, according to its nature, is then dug out from the space thus enclosed by the piles; and another crib of the same diameter as the last is laid inside the piles to afford support to them. The piles are then driven as far as possible, and more ground taken out, and more cribs put in, until the foot of the piling is approached. A crib, 18 inches less in diameter than the last, is then laid concentric with it, and so as to leave an annular space of three inches, extending round the pit, to receive a second course of piles, which are driven, the ground removed, and cribs laid exactly as before. The whole process is merely a repetition of these courses of piling, the diameter of the pit being reduced about 18 inches by each successive course. The number of cribs required to support the piles varies very much, according to the nature of the ground—one to every two or three feet being in some cases sufficient, whereas in others they may require to be placed as close as they can be got to each other. When the stone head is reached, the main, or wedging curb, is laid, and the pit walled or tubbed up to the surface, the space between the piling and the lining being filled with clay.

In Lancashire, watery drift deposits are often passed through by the system of backcasing with brickwork, as previously describ-

ed, limiting the distance between the rings to three or four courses of brickwork, and the length of the segment bricked at one time to one-eighth or one-twelfth of the circumference of the pit, and taking the precaution of hanging the rings one to another as the work proceeds, by spiking two-inch battens on the face of them. I have seen very difficult measures passed through by these simple means. Quicksands, however, cannot be passed in this way; and when these are met with, recourse is had to running drums, either of wood or iron.

Let us suppose the case of a pit where the cover is 30 yards in thickness, and composed of—

Strong Marl	13 yards.
Wet Sandy Marl	5 „
Quicksand	2 „
Loamy Marl	7 „
Quicksand	2 „
Gravelly Clay	1 „
Total	30 yards.

To pass through this with wood drums, or, as they are more commonly, though erroneously, termed, "brick drums," there would probably be required one for the upper and one for the lower sand. Each drum would lessen the diameter of the pit about 18 inches, so that to have a pit 13 feet 6 inches diameter *outside* the brickwork when finished one must have *at least* 16 feet 6 inches total diameter on first commencing the pit. For the first 15 or 16 yards the pit would be brickcased, say, 17 feet clear, inside the casing, in the usual manner. On nearing the sand the brickwork would be hung to balks stretched across the pit, either by two-inch planks spiked to the balks and to the face of each ring, or, better, by 10 or 12 iron rods, 1¼ inch diameter, passing through the lowest ring, and secured by a washer and cotter on the under side, and through the balks with a nut and washer.

A drum is then constructed of oak rings, six inches wide and

four inches thick, placed at intervals of from two feet to a yard, around which "lags" one or two yards longer than the thickness of the sand, four inches wide and three inches thick, are bolted, their edges being well joined to each other so as to form a water-tight, or nearly a water-tight casing. Round the bottom, on the outside, is bolted a "leader," which is merely a plate of cast or wrought iron, two or three feet deep, and sharp on the lower edge. This drum is then placed in the pit, and the spaces between the rings filled with brickwork to give it weight. The clay being then cautiously removed, the drum will slowly settle down, the leader cutting its way through the sand. Should the drum stick, more sand is taken out, and should it still refuse to move, recourse is had to weighting it, which is usually done by placing bearers across it near the bottom, and there making a scaffold, with a hole through the middle, of five or six feet square, the drum being then filled with bricks. Having passed through the sand, the leader would cut its way into the clay, and the sinking would then be proceeded with as before, by laying rings of the same inside diameter as those of which the drum is constructed, and bricking between them until the second sand was approached. This brickwork having been secured by spiking planks from ring to ring and to the drum, a second drum would in like manner be run within the brickwork through the second sand. The greatest care is requisite in running a drum to keep it perfectly upright, as if once allowed to get wrong, it is almost impossible to get it perpendicular again.

In some cases a drum of wrought iron is used, constructed of boiler plates $\frac{3}{8}$ to $\frac{1}{2}$ inch thick, rivetted together like the shell of a boiler. In such large shells the resistence to collapse is necessarily slight, and though in some instances they have been successfully used, yet in many cases the pit has been lost by the drum having collapsed under the enormous pressure to which it had been subjected. Wood and wrought iron drums are intended

only as temporary casings to a pit. On reaching the "fast" the permanent brickwork is brought up within the drum, the space between such brickwork and the drums being filled with clay and earth.

Cast iron drums may either be used as a means of passing a sand, to be afterwards lined to the real size of the pit with brickwork, or they may be run so as to form a permanent water-tight tub, or a part of a system of tubbing. Having recently succeeded in passing a cast iron drum through a troublesome quicksand, I cannot perhaps better describe the system than by giving an account of the means I adopted.

The pit to which I refer is the No. 9 Pit of the Rainford Colliery, and is situate about 11 miles from Liverpool, on the Lancashire and Yorkshire Railway. The cover, or drift, here consists of

	Ft.	In.
Soil	1	6
Marl	34	6
Loam	15	0
Wet gravelly Clay	16	6
Quicksand	21	0
Gravelly Marl	3	0
Total	91	6

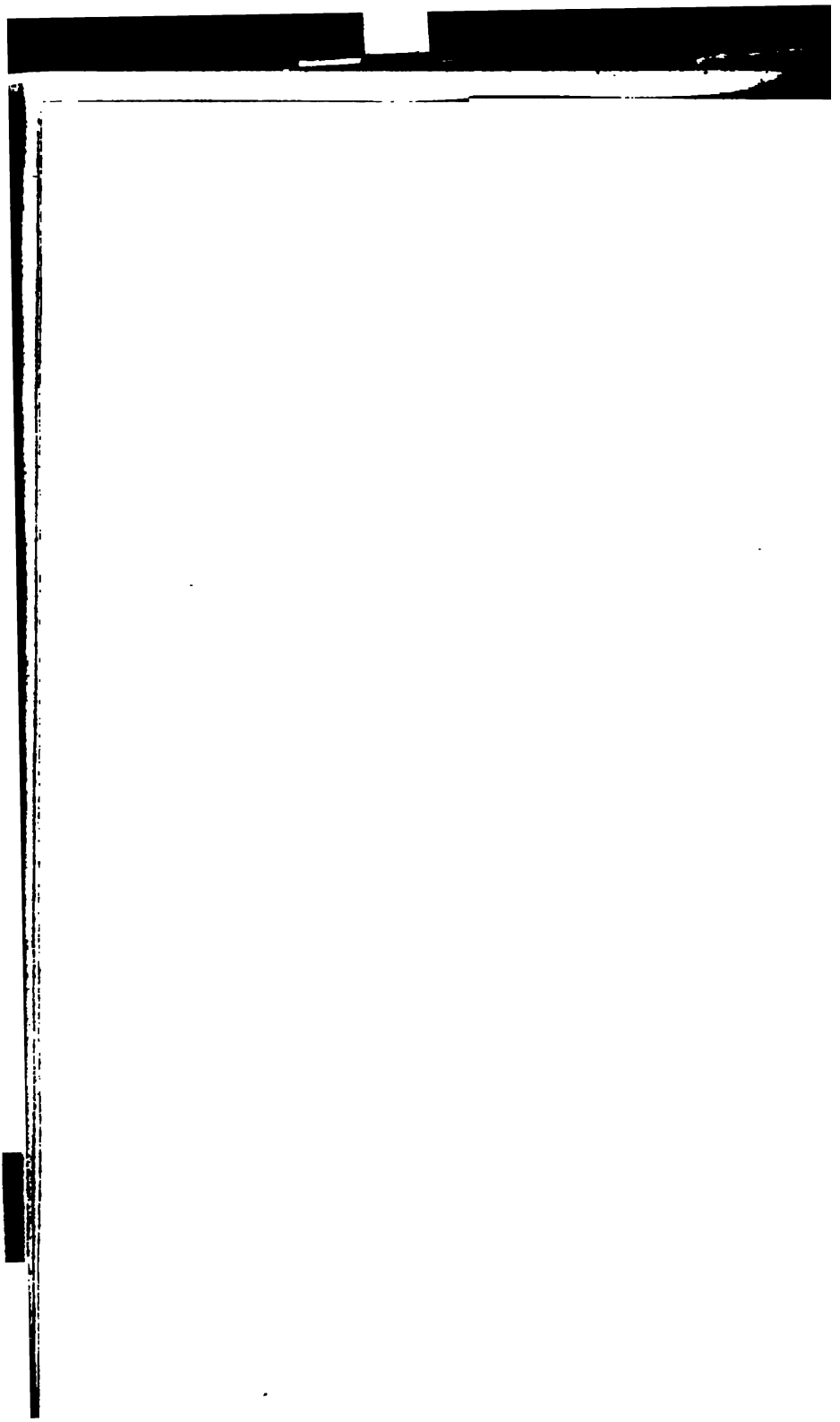
This pit was commenced in September, 1860, with a diameter of 19 feet clear, and was sunk on the usual Lancashire plan of brick-casing, but owing to the slovenly and careless manner in which the work was done, the side of the pit was pushed in by the pressure at a depth of 17 yards; and, to save the pit, a ring, 13 feet inside diameter, was laid on the bottom, and a casing of six inch brickwork brought up nearly to the surface, the space between the two casings being filled with ashes, as shewn in the upper part of Plate 1. This casing also was put in in a most shamefully negligent manner, and proved afterwards a source of

considerable trouble to us, the chief aim having apparently been to put in the greatest number of yards in the least time, and for the least money, without a care or a thought about the quality or safety of the work, or of what was ultimately to be done with the pit. Indeed the pit was then abandoned, and another commenced at a distance of 40 yards. Here the top, though troublesome, was not nearly so bad, and was passed without very much difficulty, by carrying the pit down in the usual way for 12 yards in the marl, and afterwards running two wooden drums. When I undertook the management of the colliery in October, 1861, I found they had just passed the sand in this new pit, and having found a suitable bottom, I laid a wedging ring and brought up cast iron tubbing to stop out the sand feeders. Having thus secured this pit, I turned my attention to the No. 9 Pit.

We first proceeded to lay two balks (see Plate 1) across the pit, resting on frames (*b b*) at each end, and across these two other balks (*c c*), also resting on frames (*d d*), the frames standing on a number of short planks (*j j*), placed crossways, to spread the weight and prevent the frames from sinking into the ground, as the place had formerly been a marl hole, and having been filled up with loose materials, it was very soft. On the crossed balks were erected the pulley frame and banking stage. Sinking was then resumed on the backcasing plan, taking out very short segments at a time, and putting in rings at every 18 inches, which distance, as the ground became worse, was reduced to nine inches, or three courses of bricks. We thus carried the work down within a yard of the sand. The whole of the rings were then hung by spiking two inch battens along the face of them, and to the balks above. The lowest ring was doubled, and three strong bearers placed upon it and across the pit, so as to form a triangle, on which a ring was laid perfectly level to form a stage on which to build the drum, and at the same time allow the water to be wound out of the pit.

It was my intention to use the drum as part of a length of water-tight tubbing, with which I purposed to stop out the sand-feeders. The drum was cast in segments, and was 12 feet in diameter outside; each segment was two feet deep, and 12 of them formed a course. They were made as shewn in Plate 2, with the brackets and flanges *inside*, so as to leave the back perfectly smooth, in order to receive the least possible amount of frictional resistance from the ground to be passed through. The segments were fastened together by ¾-inch bolts, ½-inch sheeting being put between all the joints. The lowest course of segments had rivetted on the back a "leader" (*a*, Plate 2), which was simply a plate of cast iron, one inch thick, in the upper part, and sharp on the lower edge, so as to cut its way through the ground. The corner, or shoulder, formed by the leader and lower flange of the bottom course of segments was filled up by a bevilled ring of wood (*b*, Plate 2), to lessen its resistance to the passing downwards of the drum, and which was afterwards removed to allow of segments being bolted below the drum, as shewn by the dotted lines of the section in Plate 2.

The lower course of segments, with the leader attached (*f*, Plate 1), was then placed upon the ring platform at the bottom of the pit, and 14 additional courses of segments built upon it, so as to form a drum about 10 yards long. Six sling chains *(g g)* were attached to the third flange from the top, and ¾-inch chains carried from these to the surface, and coupled to screws *(h)* two inches diameter, passing through the before-mentioned balks. All preparations being now made, we proceeded to lift the drum by means of the screws, and take out the platform ring and bearers, on which up to this time the drum had been resting. It was then lowered upon the clay, into which it at once sunk. On proceeding to take out the clay the sand blew up into the pit with considerable force. The screws were slackened and the drum allowed to sink very gradually, the utmost care being requisite to

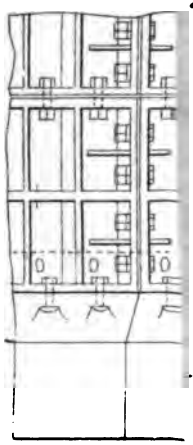


it upright. The sand was sent out of the pit, keeping the
r three feet below the pit bottom. At the end of 108 hours
its first entering the clay the drum had sunk 22 feet. Here
gan to stick, and we were compelled to weight it. We con-
ted a scaffold near the bottom of the drum, with a six feet
e hole in the centre, leaving room enough between the
ld and the bottom of the pit for the men to work in; bricks
then built upon this scaffold. On taking out a little more
the drum began to move, and sunk 2ft. 2in. in 12 hours,
ng through the sand on the rise side of the pit, and entering
velly or stony marl. We again added weight, and ultimately
d it three feet through the marl, until it lodged upon brown
on the higher side. The drum had thus run 27 feet from the
nencement.

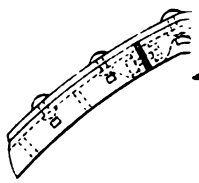
ıe most difficult part of the operation now presented itself.
dip was found to be very severe, and while the drum on the
ide rested on brown rock, rendering it quite impossible to
it any farther, on the lower side of the pit, the leader had not
ed the clay more than six or eight inches. On attempting to
ve the clay a rush of sand and water took place, which speed-
ove us out of the pit. In order to overcome this difficulty we
a number of piles (*k*, Plate 1), six feet long, six inches wide,
hree inches thick, made very sharp at the point, and drove
. longitudinally into the side of the pit, close together, under
eader, and as far round the pit as could be done. Over these
driven circle wedges (*m*) of one-inch deal, and about one foot
. These kept back the sand sufficiently to enable us to bare
ock and get in a few segments on the deep side of the pit,
d to the lowest course of the drum. We then took out the
so as to allow of this course being completed round the pit;
having sunk a couple of feet, we bolted another course to the
ne. We now felt perfectly secure, and went on sinking and
ng a suitable place for a wedging ring. This we found in a

Plate No 2

Sheigh A.B.



Leader and Lower



rum for Running

Quicksands.

Small.

Rainford Colliery.

Feby 24th 1863.

close brown linsey, at a distance of 13½ yards below the las segments. Here we laid a wedging ring (*o*, Plate 1), and brough up tubbing till we joined that forming the drum, taking the pre caution of placing an escape pipe in the closing course. Tubbin was also placed upon the top of the drum until the surface-feeder were outset, when the whole was wedged. As the shaft is intende for an upcast, we have since lined the tubbing with brickwork, a shewn in the lower part of Plate 1.

At Ryhope Colliery, Mr. Taylor, in passing through a sand successfully adopted a system of bolting cast iron segments down wards, similar in principle, so far as I understand it, to th Lancashire system of "quartering-in," but using cast segment in the place of wood rings and brickwork.

Having thus briefly described the various methods most com monly in use for passing through drift deposits, it perhaps wil not be deemed out of place if I attempt to point out the peculiari ties of each.

In the plan of timbering a pit, adopted in the North of England the whole pressure of the ground must be borne by the curbs, a the backing deals can only serve to retain any loose fragments and to transfer the thrust of the ground to the curbs. On th strength and frequency of these the stability of the work mus entirely depend. *Where the timber can be recovered* on bringing u the permanent walling, the system is economical, but I think, witl ground dry and firm enough to admit of this, many Lancashir engineers would prefer to put in the permanent walling at onc without timbering the pit at all.

In the system of brick-casing, adopted in Lancashire, when wel and carefully executed, every course of bricks, and every ring bears its own share of the pressure of the ground. No one cours

of bricks or ring can sustain more pressure than the proportion due to its depth. The rings being wide and thin, the material is disposed in the best manner to resist compression.

So, in passing through quicksand, the piles on the north country system depend for support entirely upon the curbs placed inside them, and in a pit of 20 to 30 feet diameter, the resistance of these individually to collapse is necessarily slight. It is therefore requisite to place them near together, sometimes even touching each other. This plan also entails the removal of an immense quantity of earth, from the necessity existing, where there is any considerable thickness of cover, of commencing the pit of a large diameter, owing to each course of piling lessening such diameter from 18 inches to 2 feet. When the cover is wet and difficult the expense of curbs and piles, the whole of which are lost, together with the labour incurred, is something absolutely frightful.

The wooden drums used in Lancashire are strong and compact, it being impossible for a properly made one to collapse, except by the compression of the timber itself, the lags, which are the equivalents of the north country piles, being all bevilled and accurately fitted to each other, forming a timber arch, if I may so express myself, of great strength; the rings to which these lags are bolted serving as a sort of centering, on which the arch is built. However carefully piles are driven, they can never be made thus to bed and afford support to each other. Wooden drums are generally left in, though, in most cases, with proper care the rings may be recovered, the accurate fit of the lags allowing this to be done. There is the objection against them, that they take up as much room in the pit as a course of piling; but they may generally be run much further than one course of piling can be driven.

Wrought iron drums, although occupying but little pit room,

are very liable to collapse; I have known several instances where this has occurred, resulting in the loss of the pit. They are also very difficult to keep upright.

The best kind of running drum, in my opinion, is one of cast iron, made like ordinary tubbing, but with the flanges inside. This occupies only about eight or nine inches of pit room, so that if a series were used the pit would still need only to be commenced of a reasonable size. The ground, of whatever kind it be, offers much less resistance from friction to cast metal than to wood, and its greater weight enables it to overcome a greater gross amount of friction, and so to run much further. I should not hesitate to run a cast drum 14 or 15 yards through sand, though it would not pass through anything like that thickness of clay, as wet clay has a most tenacious grip, and would sooner bring it to a stand. A cast drum is also the strongest lining to a pit which has yet been discovered; and when a drum is carefully run, and made to form a part of the permanent pit, it is the most economical way of passing wet drift deposits. There is no lost timber, no lost brick-casing, and no permanent inside walling required (except in the case of an upcast shaft), any one of which items would, in many cases, more than pay the cost of the drum.

The usual vote of thanks was passed to Mr. Bramall for his contribution; and the President having left the meeting, the chair was taken by Mr. Andrew Knowles, one of the Vice-presidents.

The Chairman, remarking that the paper contained a great deal of valuable information, invited discussion.

Mr. Goodwin—While quite concurring in the Chairman's opinion

as to the valuable character of the paper, there are many of the difficulties we find in practice which this paper has left untouched. I happen to have had a good deal of experience both of success and non-success in this matter, and I have found that the best way and the cheapest way is to use cast iron curbs. In the centre of each segment I would have a hole to let the air out. The air exercises a great effect in forcing the sand up into the middle of the shaft. The cutting curb should not be less than five feet in depth. The flange and the sand are, it must be remembered, both inside, and hence the flange offers resistance. My plan does not weaken the curb at all, because girders are used. I once ran a curb 14 yards; but I should never try that again. Each segment should have a diagonal flange to strengthen it. In sinking through 14 yards I experienced more resistance in the last three yards than in sinking the other eleven, although the material was just the same. This was owing to the great outward pressure. There is no objection to having two curbs within each other like a telescope, but in that case you must ascertain the thickness of the sand you have to cut through. One of the greatest disadvantages which are to be met with in sinking through these troublesome quicksands is that they displace too much ground, and a hollow sphere is formed, which sometimes causes the earth to give way. My plan is to send out as little sand as possible. In sinking during the last half dozen years, I have gone through quicksand in four shafts where the drift has been 45 yards on an average, and I have found the system I have spoken of answer best.

The Chairman said that Mr. Bramall appeared to have adopted the principle of commencing very largely to begin with, and going inwards.

In reply to a question by Mr. Atkinson, Mr. Goodwin said he

considered the plan of sinking described in the Paper unobjectio
able in principle. Varying circumstances might demand
modification in the details of the work.

A vote of thanks having been given to Mr. Knowles for h
services in the chair, the meeting separated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 8.] VOL. IV. [Session 1862-63.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, May 19th.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

It was announced that Mr. Thomas Wood, of Kersal Lodge, Higher Broughton, had been elected a member of the Society.

The President explained that the meeting was held a week earlier than usual, on account of Whit week falling on the week when the ordinary period of meeting came round.

Mr. Binney said that owing to his absence at the last meeting he was not able to communicate to the Society a section of the drift deposits near Rainford, kindly furnished, with some fossil shells, by Mr. Bramall. That gentleman had forwarded him a section of the beds sunk through, and the fossils found in them, just the kind of information which it is desirable for gentle-

men to transmit to the Society. It is only by such information that we can hope to obtain a thorough knowledge of the drift deposits of Lancashire. He trusted that many other members would favour us with similar sections.

The pit is near the Lancashire and Yorkshire Railway, and the following beds were met with in sinking the shaft there :—

	Yds.	Ft.	In.
Soil	0	1	6
Marl	11	1	6
Loam	5	0	0
Wet Gravelly Clay	5	1	6
Quick Sand	7	0	0
Gravelly Marl	1	0	0
	30	1	6

At a depth of 25 yards from the surface, in the wet gravelly clay and the sand, the *Turritella terebra*, *Fusus Bamfius*, *Nassa reticulata*, *Cardium edule*, *Tellina solidula*, *T. tenuis*, and fragments of other shells were found.

He did not know the level of the place above the sea, but he should not estimate it much above 200 feet, and he had great pleasure in exhibiting to the meeting the beautiful and perfect shells which Mr. Bramall had been so kind as to send him.

A vote of thanks was presented to Mr. Binney for his contribution.

Mr. John Atkinson, the Hon. Sec., said—I have here a paper that involves a question which may be interesting to the members of the Society. It is stated that at the Society of Arts, on

Wednesday Evening, a paper was read by Professor Ansted. Amongst other subjects he mentions anthracite and Boghead cannel, and he states, after reasoning on the subject, and bringing forward proof to support his position, that the Boghead mineral would never in this country have been recognized as a coal, &c. The question I want to put to the meeting is whether they consider Boghead cannel a shale or a mineral of some other character.

Mr. Hull—I think we should ascertain in the first place whether there is any lawsuit pending upon the subject.

Mr. Binney—In reading the article to which Mr. Atkinson has called attention, there is another point which the coal proprietors of Lancashire ought to consider. As for the Boghead coal, we had better keep clear of the subject altogether, for it is a very litigious question. There is one thing which Professor Ansted states which we Lancashire people, and I think the Yorkshire people too, must regard as somewhat singular, and scarcely admit to be true. He gives a description of various kinds of coal. In page 411, of No. 545 of the Journal of the Society of Arts, he says—"Some kinds of coal, especially of the Newcastle coals, cake, or run into a kind of slag, while burning; other kinds such as Yorkshire and Lancashire coals, burn through without caking, and fall to a white and red loose powdery ash." Now any gentlemen who are accustomed to good King, Yard, Orrel, Black Mine, Arley, Doe Bottom's, Cliviger, and some other Lancashire coals, will not allow this to go as correct. There are many really excellent coals here, more in number than at Newcastle, and some of them being in fact nearly as good as any you find at Newcastle for caking and coking purposes. To say that Lancashire and Yorkshire coals leave, on being burnt, nothing but white and red powdery ash is, to say the least, simply incorrect; and the opinion of a gentleman who undertakes to treat a subject when he knows so little about it certainly ought not to be taken as worth much.

Mr. Knowles—Whatever this gentleman may think it does not alter the value of the article to which he refers. As long as the proprietors can sell their coal for as much money as they ask it does not much matter about such remarks. They do not alter the market value of the article.

Mr. E. Hull—The proper way, I think, would be to answer that abstract of the report by a letter to the Journal of the Society of Arts, contradicting the assertion which is there given. There are half a dozen seams at least that make very good coke, and are used for that purpose. Anything contrary to fact ought to be put right.

Mr. Binney—There are other mistakes in the same paper. He talks about Torbane Hill mineral (No. 4 in his list), and Boghead, and other rich cannel coal like Scotch minerals, (No. 5) as if the two coals were different substances, when it is well known they are the same seam of cannel coal, there being only a fence between them, the estates of Torbane Hill and Boghead adjoining to each other.

The President—I have all my life been in the habit of naming strata, and am accustomed to the names by which they are known in every colliery district in England, and I may also add in different parts of Scotland, but never, until the trial took place between the lessee and lessor in Scotland, did I hear that a coal ceased to be a coal and became a shale, when it became a good coal. We have had general principles upon which strata have been named. Shales have been classed as a body, and the sandstones as a body, and the coals as a body. If the coal became mixed with the shale it would sometimes be called a bass, or bassy or shaly coal. Or if the shale predominated, but became impregnated with coaly matter, it would be called a coaly, bituminous, carboniferous, or bassy shale. But that the coal became a shale when it became a rich coal I never heard until this trial took place. In

fact, it is setting aside all the landmarks upon which there is any reason for guidance in the naming of strata.

Mr. Binney—One thing is certain about this mineral, that for years after it was first discovered it was called and known by no other name but parrot or cannel coal. Mr. Russel, the lessor of the mine, called it by the same names; and Mr. Gillespie, when he was first attempting to sell it, never called it anything but parrot or gas coal. I myself went and bought ten thousand tons of it as coal, and there was no dispute then. It was only when the value of the thing got up that there was any dispute. In fact, money was the origin of the dispute. I place great value on the late Mr. Peace's opinion, who, at the time he had examined the mineral, had wrought more cannel than any other man, and he, after a personal examination of the coal, and seeing it in the mine, pronounced it to be good cannel coal.

The President—The coal family is a very large one, and there is a great number of varieties. I have known some of the best splint coals of Scotland pronounced, by persons who did not know them, to be black stone. But of course a mistake in naming them so does not make them black stone and not coal.

Mr. Spence said, after all, these were only matters of opinion, and what was really wanted was some definite line of demarcation.

The President—At present we have a very good line amongst us, but, if the Professor's opinions are taken, we shall be at sea without a chart or guide of any kind.

Mr. Alderman Harvey—What is the thickness of this disputed bed?

Mr. Binney—Thirty-two inches is the greatest thickness I have

seen; but it goes to two or three inches. It comes out in large cubical blocks, just like cannel.

Mr. Hull—How long do you expect it to last at the present rate of consumption?

Mr. Binney—The area it occupies is limited. A few years, in all probability, will see it worked out. All the Scotch coals (the parrots) to us who have been accustomed to see the bright and lustrous Wigan cannel, look black and dirty. I work in Fife Pirnie parrot, and a part of the seam is so like Boghead that no one can distinguish it from that coal. Yet Pirnie or Methill has been known in the market as a coal, and never questioned, for nearly 30 years.

The President — The brownest parts of the Methill and Wemyss cannel coal are undistinguishable from the Boghead or Torbane Hill coal. As you pass from the bright cannels through to the dull blacks they become richer, and as they approach the brown they become richer still.

Mr. Knowles—What was the name given to the discovery of the mineral in North Wales, because there was a coal with it in the same mine similar to the Torbane Hill coal?

Mr. Binney said that Leeswood cannel coal had never been questioned.

The President said the Society ought to be very much obliged to Mr. Atkinson for bringing the subject forward, because, if left unnoticed, it might seriously affect the whole nomenclature of the coal system.

Mr. Knowles said this district had settled what it was; and it

was once settled in a court in Edinburgh, that it was coal. If any further change were made in sinking in any new district provision would have to be made in the lease as to whether the shafts were sunk for coal or not.

The President said it was not desirable to have these frivolous distinctions which are without a difference put into leases; there were too many already.

Mr. Atkinson—What are the strata above it?

Mr. Binney—Regular coal measures, and it had a good floor full of Stigmaria, like other coal seams. Some parts of it were brown and others black parrot. The term clay might be made the subject of as many disputes as coal, if men who know nothing about it but what they derived from book makers and hired witnesses, instead of sound practical men, who mined and wrought it, were to be consulted on the matter.

THE GEOLOGY OF MANCHESTER.

Mr. Binney presented two maps of the parish of Manchester, coloured geologically by himself, one showing the drift deposits, and the other the older stratified rocks found lying under such beds. They were made in 1861, to illustrate a paper read by him before the Geological Section of the British Association. These maps he considered more as outline than complete maps, but they would be useful to shew what was known of the district prior to the visit of the Geological Survey. All the particulars, both as to the drift and the older rocks, had been previously communicated to the Society many years ago, except in some few instances, where fresh borings and excavations had been since made.

In his paper entitled "Notes on the Lancashire and Cheshire

Drift," read before the Society on the 23rd day of December, 1842, an abstract of which was printed in the Annual Report of the Society for 1843, he gave a classification of the beds into three divisions of lower sand and gravel, till or boulder clay, and upper gravels and sands, with occasional beds of till or boulder in them. Besides these three deposits, he described a fourth, in the gravels and sands found in the beds of the valleys and low lands adjoining rivers and brook courses, and evidently derived from the first-named deposits, such valley sands and gravels being formed during the erosion of the valleys through the three more ancient beds.

With respect to the older rocks, he said that when he came into the district some 25 years ago, the local geologists always considered the Four-feet coal of Bedford, Worsley, Bury Lane, and Pendleton, to be the same as the Bradford Four-feet.

In the sinking of Messrs, Knowles's shaft, at Agecroft, the following section, kindly communicated by Mr. James Knowles, was met with :—

	Yds.	Ft.	In.
Soil, Sand, Clay, and Soft Metal ...	15	2	0
Rock	11	2	0
White Earth	1	2	0
Coal	1	0	1
Chitter	1	0	2
Rock	34	0	0
Blue Leys	5	2	0
White Earth	1	2	0
Iron Band	0	0	3
Rock Warrant	3	0	0
Rock Bands	3	0	0
Rock	3	0	0
Blue Leys	5	0	0
Iron Bands	0	0	3
Black Stone	0	0	5

	Yds.	Ft.	In.
Rock	2	0	0
Blue Leys	2	0	0
Black Bands	0	0	6
Rock	0	2	6
Warrant Earth	2	0	0
Rock Warrant	0	2	0
Blue Leys	1	2	0
White Earth	3	1	0
Black Bass	0	1	0
White Earth	1	2	0
Coal	0	0	6
Warrant Earth	2	2	0
Rock	0	2	6
Blue Leys	1	0	0
Rock	0	2	0
Blue Leys	5	2	6
Black Bass	1	0	0
White Earth	1	0	0
Black Bass	0	1	3
Coal, Four-feet	1	2	0
	116	1	11

Although the common opinion was that the two coal seams were the same, there was not much evidence adduced in support of it. On taking the strata immediately above the Four-feet coal, at Agecroft, Pendleton, and St. George's Colliery, Rochdale Road, Manchester, the two last-named points being about 2½ miles apart, and the nearest we can find, there is considerable difference, both in the beds and their organic remains, as will be evident from the following sections:—

Agecroft.

	Yds.	Ft.	In.
Blue Leys	5	2	6
Black Bass	1	0	0
White Earth	1	0	0
Black Bass	0	1	3
Coal	1	2	2

PENDLETON.

	Yds.	Ft.	In.
Blue Leys	7	1	0
Black Bass	0	1	0
Very Black Bass	0	0	8
Ironstone	0	0	2
Impure Cannel	0	0	3
Cap Coal	0	0	10
Fire Clay	0	1	4
Coal	1	1	0

The Agecroft section was about half a mile to the north-west of the Pendleton one. The same fossil fish remains, and the *Anthracoptera Browniana* of Salter are met with in the impure cannel, black bass, and ironstone of both mines, although in much less abundance at the former than the latter.

Now at St. George's Colliery, Manchester, about 2¼ miles in a straight line from Pendleton Colliery, the following is a section of the strata immediately above the Four-feet coal* :—

	Yds.	Ft.	In.
Rock Bands	3	2	0
Hard Gray Rock	5	0	0
Coal, called Nine Inches	0	0	6
Black Sod, Rotten	0	1	0
Impure Cannel Coal	0	0	6
FOUR-FEET MINE	1	0	6

Not only is there a great difference in the nature of the deposits, but there is an equal difference in their fossil organic remains, few if any of the fishes being met with at Bradford which were so abundant at Pendleton. Until the sinking of the Patricroft pit by Messrs. Lancaster, and the proving of the Pendleton Four-feet coal there, it was not easy to be convinced that the Bradford and Pendleton seams were the same; but when the author saw the red ironstone at Patricroft he immediately identified it with a similar

* For this section I am indebted to the kindness of Mr. Thomas Hill, formerly the manager of the St. George's Colliery.

bed seen on the banks of the Medlock, below the Brewery in Beswick. Now the last-named instance lies 366 yards above the Four-feet coal of Bradford, as can be proved in the river section of the Medlock between Beswick and the old ford across the river just below the iron bridge near Philip's Park, where the Four-feet outcrops. The distance is 1,100 yards, and the dip of the strata on an average 1 in 3, so that will give 366 yards between the two strata.

At Patricroft the distance in the sinking between the Four-feet coal and the red ironstone was 378 yards. From this 20 yards has to be deducted for the dip of the strata, leaving 358 yards as the thickness, so one seam is within 10 yards distance of the other—no great variance in five or six miles.

By looking at the map it will be seen that the Trias covers the upper coal-field on its dip at Ardwick, and no traces of the Permian beds which are known to be found under the south-east of the city are shewn at the surface. There is little doubt but that both the Trias and Permian beds rest unconformably on the upper coal-measures here, but they cannot be seen.

Some time since Mr. Mellor was so kind as to shew him a soft red sand without pebbles, very like the Vauxhall sand, which had been met with in driving a tunnel to the dip of the Ardwick limestones. At first he was inclined to consider this sand as Permian, but he has since come to the conclusion that it is Trias, as no Permian marls are found above it.

He had given, he said, 25 years to investigate the geology of Manchester, and the two maps, imperfect as they were, are the result of his labours. Younger geologists must take them in hand and improve upon them. There was plenty of work yet to be done before the geology of the district, six miles around the

Manchester Exchange, would be all well known, and correctly laid down. He hoped that the structure of the ground upon which the city stood would attract the attention of the members, and he should be glad to go round the town and explain what he knew about it in the field. This was what he strongly recommended, and he urged all young geologists to go out and investigate for themselves, for nothing could give the information which fine natural sections did.

Mr. E. Hull—I must say it is fortunate for Lancashire geologists, and all others, that we have a man like Mr. Binney, with his scientific knowledge, his great industry, his powerful mind, and wonderful memory, constantly on the watch to pick up and tabulate, and classify in order the various phenomena in the neighbourhood of Manchester. It is not often such an excellent local map as this has been produced in any district, and it certainly conveys a very proper and correct notion of the general structure and principal features of the district of Manchester. As Mr. Binney himself acknowledges, however, it is capable of little additions and corrections. I must beg to take a different view from him on one or two points, principally as to the formation to which the sandstone near the Ardwick limestone beds belongs. I cannot see what objection there should be to insert a little strip of lower red sandstone of the Permian formation there. This I have done myself in the map published by the Geological Survey, and I think the reasons for doing so outweigh those for the opposite course. I also consider that the Irwell Valley fault ought to be continued to the Mersey, at Heaton Mersey; and the Eastern boundary fault of the Manchester coal-field to Stockport. I also think there is a second bed of boulder clay lying above the sand and gravel, but in my general views on the subject of the drift I fully concur with Mr. Binney.

A vote of thanks was unanimously passed to Mr. Binney for his present of maps, and also for his paper.

The President asked Mr. Binney whether he still considered there was not sufficient evidence to lead to the supposition that the two Four-feet seams at Agecroft and Worsley were identical with those at Clayton and Bradford.

Mr. Binney—In position they are proved to be so.

The President—In the paper I read two months ago, I showed some little differences, indicating that they were not the same seam; but there are many points of resemblance which show that they are the same, and although it is somewhat doubtful, I have in my sections placed them side by side. I do not attach much importance to a sandstone rock being found in one place and not in another. It is a thing we find so frequently, and we often find changes in the situation in which similar fossil remains are found.

Mr. Atkinson — There is nothing more common than for a sandstone bed rapidly to pass into a shale. I know some very striking instances of this, where the coals under these are identical. There is a double bed of coal near Chesterfield, where the coal is covered by a fine crumbly shale, with nodules of ironstone, and a little further south there is a strong sandstone rock over, of the same thickness as the shale. Then, again, the cuttings at Normanton afford a striking exemplification of these changes.

After some further explanations on the maps by Mr. Binney, the subject dropped.

Mr. Binney—At a meeting held here on the 26th of February, 1861, a gentleman from London (Mr. Phillip Holland) sent some seals for locking Davy-lamps. Mr. Holland was at that time not content with stating that his seal was a very capital plan for preventing the opening of lamps, but he also made a very strange assertion. He said, "There is no well authenticated instance of explosion in a proper safety-lamp." That was the expression made use of. I then stated that this was a very serious matter, and the words I used were—"Now, I say there are many instances. The inventor of the Davy-lamp never said it was impossible to explode fire-damp by one of his lamps, because he knew it could be exploded, and he always cautioned people not to move the lamp against a current of air. We know that lamps are commonly moved against currents of air. He never expected there would be coal dust accumulated on the wire gauze, and then oil spilled upon such coal dust, and the lamp, without being cleaned, allowed to become full of flame. I have myself passed flame through standard gauze which has been covered with coal dust and oil. It is well known that lamps are frequently covered with coal dust, and nothing is more common than oil to be spilled on them. Yet here is a gentleman who sends forth to the world a lock with this dangerous advice — that a 'proper safety-lamp cannot be exploded.' I should like to ask the gentlemen present whether it is not possible to explode a safety-lamp." Then there followed a long conversation, and many of the gentlemen present wanted to make it out that they did not know of any explosion when the lamp had been properly used. Mr. Livesey, for instance, said—"I know one case where a safety-lamp did fire, and several men were killed. The men finding the lamp get hot, laid it down; the others thinking that if left it might be burnt through, one man went to fetch it, but it was so hot he let it fall, and the oil running out it exploded." This was clearly a case of working with a hot lamp and an explosion. In some mines in former times it certainly was frequently the custom to work with hot lamps. I have

been in many mines where most of the lamps appeared to be getting hot, and the men did not take the slightest notice of them. This subject was discussed at a second meeting, and many gentlemen would not admit that such lamps could be exploded. I will, however, now repeat my opinion that the Davy-lamp can be exploded. The Chairman did not commit himself so far as the rest, but it was the general opinion that the lamp could not be exploded; that lamps having coal dust about them and oil were not fit to be used; and that the lamps were not cared for as they should be. But in the north of England more decided opinions are now held. In the Mechanics' Magazine of April 17th, there is a report of the North of England Institute of Mining Engineers upon the subject. One of the greatest authorities of the day in the coal trade (Mr. Nicholas Wood) gives an opinion which is entitled to much respect. The general impression in the north, I know, has been held for a long time that the flame would not pass through proper gauze, although the South Shields committee, in their most admirable report, published many years since, declared and proved the contrary to be the fact. What Mr. Wood here says is entitled to the greatest consideration, because it is contrary to what has been advanced before, and contrary to the ideas entertained by the audience whom he was addressing. He says—"His attention had been drawn to the subject by Mr. Greenwell, who had visited a colliery where they were in the habit of heating all their lamp gauzes red hot previously to using them, to prevent their exploding the gas should they become red hot in an inflammable mixture. The subject was one of very deep importance, and he (the President) had since made one or two experiments, by inserting new lamp gauzes into the interior of a short red hot pipe, when explosions occurred from volatilization and subsequent inflammation of the oil attached to the gauze. He had tried, in a similar way, gauzes which had been thoroughly cleaned and brushed, and also others after having been steeped in and thoroughly washed with a strong solution of alkali, and the same

results followed. It seemed to him, therefore, probable that the oil was contained in the pores of the iron itself, introduced probably in the process of wire drawing. He thought that the subject should be thoroughly investigated. Several explosions had occurred where safety-lamps were in use, and which had never been satisfactorily explained. Careful experiments should be made further to prove the liability of a red-hot gauze to explode an inflammable mixture, and the circumstances under which this could occur; and if it be found that this liability really does exist, then remedial measures should at once be sought for and adopted. Some years ago he (the President) made several experiments on the safety-lamp, the results of which had appeared in their Transactions. The gas was on several occasions exploded by putting the lamp rapidly through it, after the gauze had attained a high temperature; and it was quite possible that the explosion was caused by the co-operation and subsequent ignition of the oil attached to the gauze. It would be well if these experiments were repeated to determine this. He thought the matter might very properly be left in the hands of the Experimental Committee, to arrange and carry out the necessary experiments." Now I think that after so great an authority as he saying that the gauze will admit of the flame passing through it, we should consider the subject carefully. He seems to think that some portion of the oil left in the wire in drawing it may have done it; but for myself I think in practice we could never have safety-lamps with much cleaner gauze than when they are new. They are far more dangerous when the oil has been spilled upon them after they have been covered with coal dust, and they have been handled by greasy hands. It is in my estimation a thing of great importance that a man like Mr. Wood should have his doubts as to the power of gauze in arresting the passage of flame, especially when we remember that hundreds of human lives depend upon it. It seems very strange to me that after nearly all the leading colliery proprietors in the north and other parts of England have been

preaching the infallibility of wire gauze for 30 years, the foremost man of all now says such lamps are not safe, owing to a small quantity of oil left in the wire. Surely no time ought to be lost by those who trust the lives of their men to such lamps in determining the truth of this statement.

Mr. Atkinson—It would appear that at a high temperature the gauze is not safe, but that it then sets fire to the gas on the outside. It is generally explained that the gas is not fired through in consequence of the meshes cooling the ignited gas to some extent, so that it will not flame outside. But may it not be that the gauze can get heated to such an extent that it actually fires the gas outside? I think some careful experiments should be made to ascertain this.

The President—I have met with many people in the course of my practice who have been afraid to use a new lamp in fire-damp, and I presume it must have arisen from some known explosion with a new lamp having been handed down by tradition. In South Staffordshire I have met with such cases; and so much afraid have some people been of using even an old safety-lamp that they would not use it in testing for fire-damp unless it had a double gauze. The having a double gauze, however, is, I think, going to too great a refinement, and gives scarcely any light. I believe if the lamp is in thorough order, and has had no oil spilled upon it, it is safe under any ordinary circumstances. But at the same time, in some of the collieries of this country I think we have had too much reliance placed upon the safety-lamp, more so, in fact, than is allowed in other countries. In Belgium, for instance, they actually prohibit the use of the Davy, Clanny, and other lamps which do not become extinguished in an explosive mixture, but which are used so freely in this country. That is a point, however, that is too little recognized, and which deserves more attention from our mining engineers than it has hitherto received.

Mr. Atkinson—It appears probable that at certain high tem peratures the heated wire will explode fire-damp the same as flam

Mr. Binney—All admit now that a hot wire is dangerous. B I was once in Manchester at a lecture, when the late Dr. Murr said that a Davy-lamp red hot was safer than a cold one.

The President—That is both rashness and ignorance.

Mr. Binney—Yes, and a very terrible thing to tell collier The fact is an ordinary Davy-lamp is not the thing to trust common miner with in an atmosphere of fire-damp. Man ignorant men, because this is called a safety-lamp, think it is talismanic, and safe under all circumstances, and away they g and work without any fear. Safety-lamp is a bad name und such circumstances; although the lamp is safe under ordinar conditions, and good usage, it ought on no account to be con tinually used in an atmosphere of fire-damp. If it does not g out when the gas is at the explosive point, it ought to be put ou or removed.

The President—In my own knowledge only a few years ago th safety-lamps were too frequently kept in a bad state—the pricke holes were too large, and the meshes were not the standar measure, and the parts not securely fitted together.

The proceedings then terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 9.] VOL. IV. [Session 1862-63.

The last Monthly Meeting of the Session was held in the Museum, Peter Street, on Tuesday, June 30th.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

Mr. Joseph Goodwin presented to the Society two specimens of shale, one from the Jet Amber Mine, Haughton, containing minute shells of *Anthracosia*, and the other from the Peacock Mine, Hyde, containing beautiful specimens of ferns, (*Pecopteris*), &c. A vote of thanks was passed to Mr. Goodwin for his donation.

The Secretary (Mr. J. Atkinson) in the name of the President, presented to the Society—mounted on canvass, with rollers—a copy of the Sections of the Coal Strata of Lancashire, published with the paper he read at the March meeting of the Society. The Secretary also presented in the name of Mr. E. W. Binney, Vice-President, a series of Sections through the Drift Deposits in the neighbourhood of Manchester, being copies of those previously laid before the Society on the reading of the paper published in

the Transactions. These sections are mounted on canvass, and will, along with the President's just named, be hung in the Society's room.

Vote of thanks were presented to the donors.

The Secretary said he had received the following letter from Mr. Binney, accompanied with some specimens of fossil fishes :—

Manchester, 29th June, 1863.

JOHN ATKINSON, Esq.,

Dear Sir,

It is likely that I shall not be able to attend the Meeting of the Geological Society to-morrow, therefore I beg to forward you a box of remains of fossil fishes, consisting of *Megalichthys*, *Helodus*, &c., from the roof of the Spanish Juice or Half-yard Mine at Carr Knol, near Oldham, presented to the Society by Mr. John Butterworth, of Moorside, Oldham.

Mr. Wilde, of Moor Edge, will send to the Meeting, for exhibition, a specimen of a fossil plant found in the sandstone at Oldham Edge, which he thinks proves that *Halonia* is but the root of *Lepidodendon*. This connection of the two plants, Mr. J. S. Dawes, F.G.S., of Smethwick House, asserted he had proved many years since.

Yours truly,

E. W. BINNEY.

Votes of thanks were presented to Mr. Binney, Mr. Butterworth, and Mr. Wilde for their contributions.

The Secretary announced that at that day's meeting of the Council of the Society, it had been resolved to endeavour to make arrangements for an excursion to Matlock on the 18th of August, for the purpose of meeting the members of the Dudley Geological

Society and Field Club, who expect to be there on that day. The arrangements for this excursion will be announced by circular to the members.

The following paper was then called for by the President—

ON THE EFFECT PRODUCED ON ROWLEY RAG BY HEAT; AND THE PRACTICAL APPLICATION OF ITS PRODUCTS TO USEFUL PURPOSES.

BY MR. J. PLANT.

My object in bringing the subject of the "Rowley Rag" before the members of the Society was simply to give an opportunity for the examination of a series of specimens which were obtained from Mr. Henry Adcock, the inventor and patentee of the Basaltic Stone Works at Oldbury, Worcestershire, as these works, and I believe nearly all similar works for the conversion of basalts and vitreous slags to ornamental purposes, have been discontinued, and consequently opportunities may not be very common for the examination of the interesting results of the experiments.

The question as to the changes which heat has effected in the constitution and crystallization of certain igneous rocks has ever been one of great interest to the geologist; and with a view to explain certain theories upon the columnar structure and prismatic form of basalt, as observed generally, but more especially at the Giant's Causeway, Staffa, and the hill at Rowley Regis, experiments were conducted as early as the year 1804, by Mr. Gregory Watt, which experiments established the fact that basalt

and trap were igneous rocks, and that the columnar structure of basalts could be experimentally produced under certain conditions of heat and pressure.

Rowley Rag, has been described by Senft as *Melaphyre*, an indistinctly mixed rock, intermediate between ordinary greenstone and black basalt, of dirty greenish brown, hard and tough in a fresh state, having a specific gravity of 2·85, and a composition of silica, 55; alumina, 25; oxides of iron and manganese, 12; lime, 8; soda, 6; and inappreciable amounts of potash and magnesia.

Mr. Watt fused 700 cwt. of this material and kept it in a furnace several days after the fire was lowered. It fused into a dark-coloured mass, of a vitreous character, with less heat than was necessary to melt iron; and a portion which was taken out whilst the mass was in fusion, and cooled quickly, became perfectly glassy. As refrigeration proceeded in the mass, it became changed into a stony substance, and globules appeared; these enlarged, till they pressed laterally against each other, and became converted into polygonal prisms. The most important result observed was the formation of spheroids, sometimes extending to a diameter of two inches. They were radiated with distinct fibres, in somewhat concentric layers; but the centres of most of the spheroids became perfectly compact before they attained the diameter of half an inch. This structure gradually pervaded the whole body of the spheroid. A continuation of the temperature speedily induced another change; the texture of the cooling material became more granular, its colour more gray, and the brilliant points larger and more numerous. These brilliant molecules arranged themselves in regular forms, and finally the whole mass became pervaded with thin crystalline liminæ.

Mr. Watt applied these facts in explanation of the globular

structure which is observed in decomposing basaltic rocks; and as similar experiments have been often repeated, the results are familiarly known to every geologist, and need not to be further alluded to in this paper.

Sir James Hall, in 1805, conducted experiments, illustrating the crystalline arrangements and texture assumed by basaltic rocks when fused and cooled under high pressure. He established the fact that most rocks of presumed igneous origin, when fused, yielded different products according to the differences in the amount of pressure under which they were cooled. Thus when the rate of cooling was rapid, they formed a black amorphous glass; and when the cooling was slow, a strong mass with a granular structure. The same materials yielded the most dissimilar products, a fact that is of the greatest importance in reference to the study of the nature of eruptive rocks, and of the metamorphic action which they occasion.

These discoveries were chiefly valuable from their philosophical bearing upon contested points in the science of geology; and it was not until the year 1846 that any attempt was made to turn them to a practical and economical value. At that time, acting upon the results of some experiments which had been made upon the continent, a Mr. Jean Michel Borgognon took out a patent in England for the manufacture of articles of utility in what he termed Artificial Basaltic Lavas. His invention claimed the discovery of operating upon stony substances, but chiefly upon the vitreous slags from iron furnaces. These were fused at a high temperature, and run into moulds of cast iron, or refractory clay, the moulds being heated in the interior by means of a powerful flame, kept up by a blast. Colouring matter, from the oxides of iron, and other metals, was mixed with the fused materials, and great diversity and beauty was thereby obtained in the vitreous

ornaments. It does not appear, however, that any great application of his patented lavas was made in England.

In the year 1851 Mr. Henry Adcock, a civil engineer, of Oldbury, took out the first patent for the production of bricks, tiles, pipes, &c. from the fused trap of Rowley Regis. This gentleman had been led to the application of this material from experiments which he had commenced in the year 1834. He then fused some Rowley Rag in a common kitchen fire; and being much impressed with the beauty of the black glass, as it fell on the hearth, he perceived that it possessed a probability of great practical value. He obtained the use of a reverberating furnace, and conducted his experiments upon a larger scale. In 1851 a patent was obtained, in which the inventor claimed for his discovery in melting the stony material, known as Basaltic Trap, Rowley Rag, or Whinstone, and running the same when in a fluid state into moulds. The materials were heated in a reverberating furnace, either at the bottom, or in crucibles, and then cast into cast-iron moulds, put together with iron cramps. The fused trap was run into the moulds, when both were brought into a state of white heat. If it were intended to give a polished surface to the casting, the cast iron mould was highly polished and coated with plumbago, also highly polished. If the fused materials were allowed to cool at a gradual and slow rate of cooling, the result was a hard stony rock, scarcely to be distinguished from the original trap from Rowley Regis; but a less degree of heat, with a quicker rate of cooling, caused the materials to assume the appearance of a mixed marble; and a rapid rate of cooling produced a black glassy substance, quite opaque, unless it was cast very thin, and then it became semi-transparent. If it were desired to run the fused materials more quickly, a flux, such as soda, effected such a result.

The practical utility of this invention became widely known, and an extensive application of it was made in ornaments of an

architectural character, mantel pieces, window sills, window heads, string courses, capitals of columns, and monumental slabs, which were all cast from Rowley Rag: and these, from the almost imperishable nature of the material, are likely to endure for ages. For reasons which it is not necessary to state the works did not long continue, and have since been taken down.

In 1852 Mr. W. G. Elliott, Blisworth, took out a patent for the manufacture of pipes and other articles from mixed brick clay, limestone, ironstone, and oyster shells. The product was a greenish black vitreous material when run into press moulds and afterwards annealed. There is very little difference between this application and that of Mr. Borgognon, and it added nothing which was not well known in the effects of heat upon minerals.

In 1854 a patent was taken by Mr. J. T. Chance, of Birmingham, claiming improvements in the manufacture of articles from the mineral called Rowley Rag, in which the principal discovery, in addition to what had been known of its fusibility and of its adaptation for casting in moulds, was, that the fused mineral, unlike cast iron, was capable of being rolled or pressed into the form of slabs, sheets, bars, and rods, all either with plain or raised ornamental surfaces. In fact it could be treated in the same manner as plate glass, and some of the ductile metals; but articles manufactured in this way required to be subjected to the process of annealing.

Another discovery was made about this time, in which it was shown that it was possible to mix a quantity of coloured glass with the fused Rowley Rag, for the specific gravity of basalt and common glass, when in a state of fusion, are nearly alike, and advantage was taken of this to produce sheets of the material which, when polished, resemble the rich and beautifully coloured serpentines of Cornwall. In fact there was no limit to the variety

which could have been obtained by the admixture of these two and other substances—the only point of any scientific interest in the matter being that the two materials did not chemically combine even with the greatest amount of care and skill. They were only mechanically mixed together, and the result is well shown in the specimens upon the table.

In 1855 Mr. Chance and Mr. Adcock took out a further patent for improvements in casting articles from the slags of iron furnaces, but this chiefly related to the machinery and method of casting in sand moulds in place of the iron moulds first used by Mr. Borgognon; and since this date no further discoveries appear to have been made in the practical application of the basalts and traps for economic purposes, or in the aid of the decorative arts.

The specimens which I have to exhibit were obtained from Mr. Adcock, the inventor and proprietor of the Basaltic Stone Works, at Oldbury, Worcestershire, after the works were discontinued:—

No. 1—A specimen of Rowley Rag in its natural state.

2—A shining opaque glass—artificial obisidian—the common result of the Rowley Rag when cooled very quickly.

3—A specimen showing the conchoidal fracture, which is common to the fused as well as to the natural state of the Rowley Rag.

4, 5, 6—Specimens showing different amounts of recrystallization in accordance with the rates of cooling. In No. 6 the greatest degree of change ever obtained is shown, other than its entire conversion into basaltic stone.

7—Is a specimen showing that in some instances the recrystallization takes place in bands.

8—Is a casting of part of an ornament, exhibiting its perfect reconversion to the Rowley Rag.

9—A specimen broken from a large mass of the recrystallized basalt.

10—Specimen resembling a natural vesiculated lava. When fused the Rowley Rag is very viscid, therefore if a piece of wood, coal, or any other substance

which will give off gas be plunged into it, the escaping gas will produce this vesiculated structure.

11, 12—Are from the bottom of the furnace, in which the quartz gravel lining the furnace has become embedded in the melted lava. These specimens are very similar to the toadstones and amygdaloid porphyries frequently met with in basaltic districts.

13—Is a portion of the congealed coating which is instantaneously formed in the ladle used in pouring the melted matter into the mould. This is very similar to the crust which is observed on flowing lava from a volcano, and in a great measure preserves the under mass from cooling quickly. It was turned to advantage in casting, as the fused basalt would remain for more than an hour in the ladle when thus coated, and experience taught the workman that fused metal so retained made castings of a superior character. When a ladle was once coated to the thickness of half an inch it gained comparatively little in thickness, even when refilled three or four times.

14 to 19—Are polished specimens of Mr. Chance's rolling of the obsidian glass, from $\frac{1}{8}$th of an inch to $\frac{3}{4}$ thick, used as a substitute for roofing slates, Bath tiles and inlaid work for halls. These sheets were rolled eight feet long by three feet eight inches, and were readily cut into lengths with a glazier's diamond. Nos. 16 and 17 are coloured by a mixture of glass. No 18 has a design engraved upon the polished surface by means of fluoric acid, showing its adaptability for this character of decoration. No. 19 has a large per centage of glass, and coloured by a metallic oxide.

20—Artificial obsidian, cast in a cold iron mould.

21— Ditto, cast in a heated iron mould.

22—Part of an obsidian pipe, cast in a heated iron mould.

23— Ditto cast in a damp sand mould, a hollow column, six feet high, seven inches diameter. One inch thick of this kind resisted a pressure of 300 tons. A pipe four inches in the bore, and half an inch thick, resisted a hydraulic pressure of 220 pounds.

24—Artificial obsidian, with fine conchoidal fracture.

26, 27—Three specimens: Artificial obsidian.

The thanks of the Society were voted to Mr. Plant for his paper.

The President then introduced to the meeting Signor Berruti, of the Royal Geological Survey of Italy; and invited that gentleman's opinion upon the paper which had been read.

Signor Berruti said that although he could not speak English sufficiently to use the technical words which such a subject demanded, he was very pleased to have an opportunity of meeting the Society. In the course of his geological researches he had been in different volcanic districts where phenomena occurred similar to those exhibited by the specimens on the table; and he had had frequent opportunities of examining streams of lava which showed all the varieties of texture from compact basalt to those of obsidian and pumice. What he had seen made him quite agree with the views expressed in Mr. Plant's paper. In the neighbourhood of a volcano might be seen rocks of considerable thickness which at the top consisted of obsidian or volcanic glass, lower down the texture was of a duller and more earthy or stony character, and lower still, where the mass must have been a long time in cooling, it was very similar to basalt or Rowley Rag, being hard and of a sub-crystalline texture. It appeared quite clear that parts of the same mass of lava became a compact stone like basalt when cooled slowly, and other parts, when cooled rapidly, became obsidian, for near Naples, a stream of lava, which had flowed into the sea, was converted into obsidian where it had been immersed in the water and quickly cooled, whereas, on the land, where the lava had cooled slowly, it had become more crystalline and approximated in texture to basalt,—the material being evidently similar in both instances. In Italy an attempt had been made to turn it to some use, and to a certain extent the experiments had been attended with success. At the same time it was not yet considered that the success was complete.

In answer to a question, Signor Berruti said he did not consider that the moulded ornaments manufactured from fused basalt had

a tendency to decay or become decomposed by exposure to the atmosphere. He believed they would be found very durable when used in buildings.

Mr. Atkinson—In the section of a bed of lava, for instance of the depth of fifteen or twenty feet, (or of the height of this room,) have you ever, in the lowest portion which had sustained the greatest pressure, or in the part where it had been longest in cooling, observed that it assumed a crystalline structure similar to granite?

Signor Berruti—No. The material is more compact. It shows traces of crystalline structure, but the crystallization is very different from that of granite.

Mr. Hull—I have listened with very great pleasure to Mr. Plant's paper. If there is one question more than another we may consider absolutely settled in geology—though some Geologists deny that anything at all has been settled—it is that these different varieties of trap, passing from greenstone and basalt into obsidian, are the result of differences in the rate of cooling under pressure. But when we come to the question with regard to granite, there, at once, we perceive a distinction. There is something very different and distinct between granite and lavas, and other trap rocks. The great question is why there should be such a distinction. We all know that granite is a highly crystalline rock, and I think the reason that we fail in making any approach towards forming granite by artificial processes of cooling is that we are attempting to do, on a small scale, what nature does on an enormous scale, and with overwhelming forces and length of time in her own laboratory. We can make no approach to the enormous pressure that nature has been able to employ during the cooling of the granite; nor can we lengthen out the time which granite has taken to cool within the bowels of the earth.

It is now known by clear observation, some of which has been made in Dartmoor and other parts, that granite is nothing else but the melted stratified rock, passing sometimes into slate rocks and so gradual is this passage, that it is sometimes difficult to say where one form of rock commences and the other begins. This shows us that granite is the result of metamorphosm of the stratified rock at an enormous depth, in all probability, when the rock was overlaid by many thousands of feet of strata, which have been since removed. Thus in Devonshire, in the case of the granite of Dartmoor, the bosses of granite which appear there lie in the very strike of the beds, and occupy the place of certain members of the slate rocks of that district. Nothing could better prove that granite is a highly metamorphosed form of stratified rocks. I am extremely sorry to find that these interesting experiments alluded to by Mr. Plant are not being carried out. These specimens upon the table are exceedingly beautiful, and when we recollect the large number of ways by which they could be utilized, it does seem extraordinary that the process has not been turned to some more practical account than it has at present. Signor Berruti tells us they are making attempts to turn this process to account in Italy, and it is to be hoped they will be more successful than in England.

The President.—Mr. Hull has told us about the numerous points which have been settled in geology, and that if there is any one which is settled it is this one. I have now been a pretty long time engaged in pursuits which have given me very great opportunities for observing the geological structure of the earth,—not only opportunities of seeing what is on it, but also in it. In the course of those opportunities I have examined rocks similar to those exhibited to-day, both in Northumberland, Cumberland, Durham, Westmoreland, Cornwall, Devonshire, North Wales, and in many portions of Scotland, at the Giant's Causeway and Fair Head, in Ireland, also in the South of France, in Saxony, and in

the Hartz Mountains, and other places which I cannot now recollect. As the result of my observations I am prepared to admit that the fusing of these rocks does give results similar to what are occasionally found in nature; but with regard to the origin, I am disposed to think Geologists have settled far too much, and will have to unsettle a good deal of what they have decided upon, and begin *de novo*. A great many valuable facts have been accumulated, but they have been put too hastily together. The way in which many of the trap rocks are found blended with the slates, &c., is in itself to my mind a point of difficulty to be got over before we can recognise them as being formed by igneous action. The way in which what are called the floating whins of Scotland are found interspersed with the coal-measures lying in a semi-stratified slate, and which are supposed to have emanated from a chimney and overspread the coal-measures, has caused them to be quoted as of igneous origin. For myself I have never met with a chimney, nor have met with a person who has seen it. I myself have sunk shafts through these trap or basalt rocks, and have seen no difference as I proceeded downwards. There has been uniform structure throughout. I have also made many experiments with them; and I find generally there is a difference in what is obtained after melting, there being on the whole a more glassy structure obtained. The variation of the crystalline structure which Mr. Plant has pointed out is certainly very interesting, but it may possibly be accounted for otherwise than by the way it has been cooled. I know that the structure of certain metals becomes varied by a different process of cooling, and that certain metals when mixed together become crystallized sooner than others, and have a tendency when cooling to form aggregations together; and upon this beautiful law is founded Pattinson's principles of extracting silver from lead. By analysis myself I have found out that when there is a granular structure of the scoriæ of the cinders from the blast furnaces of iron works, they generally contain more iron than those which have a glassy

structure, and by this structure I could tell you to within one
two per cent. how much of iron the cinder contained. I thi
under all the circumstances we should do wisely to regard facts a
observations simply as such, without being too hasty in jumping
conclusions. The scoriæ and remains of volcanos are different
trap rock, the latter, in my judgment, having been deposited
the same time as other strata.

Mr. Chatwood said he should like to ask whether there was a
chimney in the basalt at Dudley.

The President—It appears to be an outburst of rocks belo
and seems to have originated in the same way as other traps, a
without any chimney. Independent of the Rowley Rag there is
South Staffordshire a floating whin or semi-stratified whin, whic
I have seen in the coal-mines there, and which seems similar to th
floating whin of Scotland.

Mr. Atkinson—They considered near Darley Dale that they cam
upon one of those pipes of outburst, and went down a gre
distance, if my memory serves me rightly, 200 yards, witho
getting through the toadstone, and gave up the sinking, co
sidering they got upon the outlet of the igneous mass. It w
considered in Derbyshire by many miners that the toadstone di
come out at certain points, and floated over and became inte
stratified with the limestone.

Mr. Hull, in reply to a question from one of the members, sa
there was no question whatever that the Rowley Rag is a tr
basalt due to igneous action. The thick coal had been followe
under the basalt, till it was found so charred as to be worthless.

Mr. Plant, in replying on the whole discussion, said he w

quite satisfied with the remarks of Signor Berruti, to the effect that we were only doing artificially what was done by nature in all volcanic districts. He (Mr. Plant) could have brought some specimens of volcanic rocks that would have been a counterpart to those specimens of Rowley Rag which had been laid upon the table. The reason perhaps why the experiments to which reference has been made had not succeeded, was because the production was too costly to make the affair very profitable, especially considering that the raw material could be got for almost nothing. All Manchester was paved with a material, brought from Wales, similar to Rowley Rag.

The discussion then ceased.

ON THE

LIBERATION AND DRAINAGE OF GASES FROM COAL-MINES;

BY MR. JOSEPH GOODWIN.

The subject under consideration is one of considerable importance to all connected with the working of coal-mines, but more particularly so to those who have to meet the dangers consequent upon earning a livelihood even in the best regulated collieries. It is therefore of importance that all the facts bearing upon the subject of the liberation or drainage of gases from coal-mines should be given due publicity to, more especially so if they are of a nature calculated to render accidents in mines less numerous. This is my apology for bringing the subject before you in its present form. The gases that are usually met with in coal-mines are carbonic acid and light carburetted hydrogen, which are perhaps better known to the collier by the names of black or choke damp, and fire-damp. Occasionally carbonic oxide, sulphuretted hydrogen, and other gases are met with in such forms as to clearly point out the importance of considering no place in a colliery either

healthy or safe without being thoroughly ventilated. What ha
been the precise circumstances under which the light carburette
hydrogen of our coal-mines has been formed must to some exte
be a matter of conjecture, but yet, I think, it will be admitted tha
it has been formed by the slow decomposition of the vegetabl
matter that has formed our coal seams. The causes that operat
in producing the other gases that are met with in coal-mine
are numerous. For instance, we have the decomposition of co
in situ, as well as the decomposition of iron pyrites and othe
minerals, which are left in the goafs or old workings. Th
rapid decay of timber and other substances, owing to the humi
and moist state of the atmosphere, is also a fruitful source o
deleterious gases. We have also the gases formed by th
breathing of men and animals, the combustion of lights, th
blasting of coal by powder, and other causes, which operate i
rendering the atmosphere of the mine impure. It is hardl
necessary to remark that the light carburetted hydrogen is by fa
the most dangerous gas that we meet with in working collieries
as well as the most abundant. The circumstances under whic
this gas is given off from colliery workings varies to some exten
Sometimes it proceeds more freely from the roof of the mine tha
the floor, and *vice versa*, but in either case it is also given off fro
the coal seam. Carbonic acid gas, although so frequently found i
collieries, does not appear to be given off from the coal itself.
have only seen two cases at all supporting the theory that
emanates from such source. Yet I have been endeavouring t
satisfy myself upon this point for many years. One of the case
referred to was in close proximity to a fault, and in the other it wa
just possible that the gas might have come from some other sourc
than that of the coal. The remaining gases that have bee
mentioned, although occasionally found in coal-mines, have no
yet been proved to emanate from the coal. It may not be deeme
out of place if I here refer to a case, that has recently come unde
my notice, where carbonic oxide, or white-damp, has been found i
the workings of a colliery. In the case referred to a level wa

being driven, which came in contact with a dirt hole that had been driven and filled with dirt many years previous, out of which a considerable quantity of gas escaped, which did not at all affect the burning of the candle, yet produced such an effect upon the men as to render it impossible for them to stop in the place more than a few minutes at a time. It continued to escape from the dirt hole for several days, but gradually diminished in quantity. As previously remarked, the circumstances under which gases are liberated, or drained from coal seams, varies considerably. It would, therefore, be vain to attempt to lay down a rule by which to judge of the distance that a coal seam can be affected from the drainage of gases by working out an upper or under seam. But if the distance cannot be accurately determined, we may, by collecting all the information in our power, and carefully recording all the facts that come under our own observation, arrive at an approximate idea, and thus tend to check any wild or random statements that may happen to be made upon the subject. I can conceive that gases may be liberated or drained from coal *in situ* by working an under seam, the falls of roof which reach up to an upper seam, or by working out an upper seam, separated by only a few feet of strata from an under one, in which light carburetted hydrogen exists under great pressure; or that in opening out a maiden field the exploring drifts may drain the drifts that follow them. But I cannot conceive how it is possible for a mine to be drained of carburetted hydrogen by working another seam at a distance of 30 yards, or anything approaching to it. Yet I believe it to be the opinion of some that the drainage of gases has affected mines at a much greater distance than that named. Several cases have, however, come under my own observation where coal seams have been worked at distances varying from 4 feet to 14 yards and upwards without producing any such effect. Perhaps I cannot do better than cite a few well authenticated facts bearing upon the subject of the drainage of gases. The first case that I shall refer to is one that occurred at Clayton colliery on the 14th of April last. Sometime previous to that date we commenced driving a brow in

the Four-feet Mine, for the purpose of pumping the water up, on the one side of which was the engine brow, at a distance of 26 feet, and on the other side the return air-course at a distance of 10 feet, besides which levels had been driven at right angles to the brows at a distance of 12 yards from each other. In driving the brow referred to we found that a considerable quantity of carburetted hydrogen was given off from the coal almost the whole length of the brow; and on the morning previously named, a space of more than 30 cubic yards was filled with explosive gas in less than an hour. The engine brow return air-course and levels have been driven more than 11 years, and therefore the gas had had length of time enough to have drained from the coal if it would have drained at all. The place was perfectly free from any fault, and the coal of such a character as to impress any one with the idea that everything was favourable to the process of drainage. The thickness of strata or depth from the surface at the point referred to is over 300 yards. In the Peacock Mine, at Hyde Colliery, two levels had been driven for many years, and were being worked back towards the shaft, when the roof of one of the works fell, and rendered it necessary to cut up within a foot or fifteen inches of the old working face in order to regain it. In so doing a considerable quantity of gas was given off, although on the one side was a thrill or cross-cut at the distance of three yards, and on the other side, as previously stated, not more than fifteen inches of coal, to where a current of air was passing. The distance between the levels in this case was from eleven to twelve yards. A still more striking case occurred at the same colliery in driving a pair of brows in the Black Mine, at a depth of from 300 to 400 yards from the surface. The brows were being driven from the main level and intake air-course, and had been driven some two or three yards each in the bottom coal when a drill hole was made in the top part of the coal, for the purpose of inserting a plug, to which to attach the sights by which the brow was to be kept in its proper direction. The drill hole was not more than eight inches in depth, yet it liberated such a quantity of gas that it was with difficulty extinguished after

it became ignited. The thickness of the bottom coal was about two feet nine inches, and the tops about two feet one inch, separated by a shaly parting of not more than an eighth part of an inch in thickness. The level out of which the brows were driven had been opened for nearly three years, as well as a parallel level at ten yards above it. In this case it is clear that the drainage had not extended to nine inches. For the following information I am indebted to my friend, Mr. Horsfall, of the Fairbottom Colliery, near Ashton-under-Lyne. He says—"In our Black Mine at the Broad Oak pit we have a rank of coal 120 yards in length, and 10 yards in breadth. At the top side of the pillar it is all old works, but they are thoroughly ventilated. At certain distances we make cut-throughs, and when driving these we experience the greatest difficulty from the time we have cut two or three feet up brow, in consequence of the gas that is given off from the coal. The pillars above the rank referred to have been worked out a considerable number of years, consequently I think the gas has had every opportunity of being drained in that length of time, if there had been any possibility of such a thing." At the same pit, in driving through a pillar of coal only five feet in width, considerable quantities of gas were given off from the coal. At the Heys Colliery, belonging to the same firm, two mines are being worked at a distance of fourteen yards from each other. In the bottom seam they are and have been getting pillars or working back the coal for some time. In the upper one narrow work is being driven previous to removing the pillars, or commencing "robbing." Yet the upper mine gives off a great quantity of light carburetted hydrogen gas. The foregoing are not the only cases that I could cite tending to show that the distance that gases will drain from a coal seam under ordinary circumstances is very limited indeed. But I think enough has been said to point out the importance of considering no place in a colliery safe or free from explosive gases unless it be properly ventilated. The difficulty in impressing the workman with a sense of the danger by which he is surrounded forms one of the drawbacks that is experienced in endeavouring to

reduce the number of colliery accidents, therefore too much publicity cannot be given to sources of danger that by some are considered not to exist. The pressure of the atmosphere doubtless exercises some influence upon the escape of gases from coal seams, but to what extent I am at present unable to say, although I am making observations with a view of bringing the subject before the Society at some subsequent period. It is hardly within the scope of the present paper to speak of the nature and properties of the gases that are met with in coal-mines, but I may briefly refer to the fact that the law of diffusion of gases appears to act more tardily in the mine than in the chemist's laboratory. Most of you present will doubtless be acquainted with the experiment of placing a vessel containing a light gas over one containing a heavy gas, and that the two gases will thoroughly mix with each other. If the lower gas is more than 20 times the weight of the upper one the diffusion takes place in a few hours' time, and the proportions of the two gases are the same in each vessel. In the mine, we, however, invariably find the carbonic acid gas occupying the lowest position, and the light carburetted hydrogen the highest. I have seen the carbonic acid gas occupy a position in the lower side of a wagon road for upwards of 50 yards, the whole of which distance was so charged with the gas that a light was extinguished, by putting it into the gas, as suddenly as by immersing it in water. Yet on the higher side of the same place a light would continue to burn in an ordinary manner. On the other hand, I have crawled nearly a hundred yards along a level where the gas would explode on the higher side for the whole distance; and in the lower side its presence could not be detected in the safety-lamp. In fact every day experience proves beyond doubt that the light carburetted hydrogen gas occupies the highest stratum in the atmosphere of the mine, and the carbonic acid gas the lowest, if any such gases are given off or generated. This law is not confined to places that are imperfectly ventilated, as supposed by some, but to the dead ends or places where no current of air exists. It is possible that the difference may be caused by the gases being generated or given off

more rapidly than the law of diffusion acts. It has been suggested that more time is required for the perfect diffusion to take place than is generally allowed before the gases are disturbed, but this, I think, scarcely meets the case, for I have seen places containing the gases referred to, which, after being undisturbed for months, have followed the same law. Yet if we admit the principle of the lightest gas occupying the highest position in the mine, we ought to have the highest stratum of the atmosphere less explosive than the stratum which is rendered heavier by an admixture of atmospheric air, that gives to light carburetted hydrogen the greatest explosive power, or, in other words, the greatest power of explosion is given to light carburetted hydrogen when it forms somewhere between one-eighth and one-tenth by volume of atmospheric air; and since the light carburetted hydrogen gas is little more than half the weight of atmospheric air, it must follow that the specific gravity of fire-damp decreases the less proportion of air it contains. When the admixture of fire-damp and atmospheric air is found in the proportions of five parts of air and one of light carburetted hydrogen, it ceases to be explosive, therefore, upon the principle of the lightest gas occupying the highest position, we ought to have a non-explosive mixture in the highest stratum, but this, however, is not the case. For it is well known that fire-damp is met with in many places where at the floor its presence cannot be detected in the lamp, but by raising the lamp a little, the flame becomes elongated and of a light blue colour; and as the lamp is raised the flame gradually increases, until at the roof of the mine it will explode and fill the lamp. The same principle applies to any workings that are driven up brow, and to which law or principle, I believe, there is no exception.

A Vote of thanks was given to Mr. Goodwin for his paper.

Mr. Horsfall, in corroborating the instance mentioned in the

paper, said the coal in question had been worked before for man years, and in driving cut-throes he met with gas in every one.

Mr. Farrimond said the coal must be very thin to allow the ga to stand so long a time. He should have thought that the ga would have come from the old workings above. Was there an ventilation?

Mr. Horsfall said there was a complete air current going alon the face.

The President said there was always more of the steady discharg of gas in driving out in the solid coal than afterwards.

Mr. Horsfall said his opinion was that it drained to a certain extent, but not thoroughly.

Mr. Hull said it was not necessary that there should be a fissur for the drainage of gas from the coal. If there was no fissure, small portion of solid coal would be sufficient to retain the gas.

The President said that wherever a fissure filled with clay wa met with, independent feeders of gas were met with beyond it.

Mr. Chatwood—Do I understand Mr. Goodwin's opinion to b that the gas we find in coal pits is not manufactured by that mine

Mr. Goodwin said he believed that the light carburette hydrogen gas had been pent up in the coal since the time of th decomposition of the carbonaceous matter that formed our coa seams. At the same time, he was bound to admit that coal *in sit*

was undergoing decomposition and was making a good deal of carburetted hydrogen. There was nothing to make him believe that carbonic acid gas came out of the coal itself.

Mr. Atkinson—Do you mean that the carbonic acid gas, now found in coal-mines, was formed when the vegetables were converted into coal, and that it has been pent up ever since?

Mr. Goodwin—No, I say that carbonic acid gas although generated in coal-mines does not come from the coal itself. I think no stronger proof need to be adduced than the fact that it is seldom or ever found before gobs or goafs are formed, after which, it is almost certain to be found if the old workings are penetrated.

The President—Fire-damp is the only gas I know of that comes out of coal accompanied by sound, and generally if you throw water upon the coal giving off fire-damp the issue will be audible. Other gases come without any noise; and although I am not prepared to say that the view which Mr. Goodwin takes is not a correct one, I always hold that there are mines that give off carbonic acid gas as well as fire-damp, and also that they sometimes give off white-damp, which is a gas that will support combustion, but will not sustain life. I am sure we are all immensely indebted to Mr. Goodwin for his paper, which is of great value to our rising young miners. This subject should be especially interesting to them, and will be of great service.

Mr. Henry Baines said he had seen carbonic acid near the floor, and fire-damp in the roof in the Doe Mine at Kearsley. On one occasion he had some white-damp hanging about his clothes, and when he got home his little child, who came and sat in his lap, was seriously affected.

The President—This white-damp is exceedingly difficult to detect, and we have not in fact any common mode of detecting it as we have other damps.

Mr. Baldwin said it would be a very good plan if gentlemen who were in the habit of going into these mines would carry with them some vessel, and collect these various gases for careful analysis; they would be doing the Society great service.

The proceedings terminated with the usual vote of thanks to the Chairman.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 10.] VOL. IV. [Session 1863-64.

The Annual Meeting of the Manchester Geological Society was held in the Museum, Peter Street, on Thursday afternoon, October 29th, 1863.

JOSEPH DICKINSON, F.G.S., the President, in the Chair.

The object for which the meeting was called was to receive the reports of the Council, of the Curators, and of the Treasurer, and to elect officers for the ensuing session, as required by the Rules of the Society.

The President said—We have now arrived at our 25th Annual Meeting. The reports will give you an account of what has taken place, and I do not know that there is anything I need say, except that the Society has been in a very prosperous state during the past year. We have had some very excellent papers brought before us, and the attendance of members at the meetings has been good. Independent of that, the Society has done a great deal of good by the publication of papers read, thus enabling those who could not attend the meetings, or become members,

to make themselves acquainted with our transactions. In this way matter has been brought under the notice of subordinate persons in mines, which has proved of great service.

Mr. J. Atkinson, Honorary Secretary, then read the reports.

Honorary Curators' Report.

The Honorary Curators reported the receipt of the following donations in the course of the last session:—

FOSSILS, &c.

Presented by Mr. Lynde, Jun.—

1.—A specimen of Pecopteris, from the Gloucestershire Coal-field.

Presented by Mr. Joseph Goodwin—

2.—Two Specimens of Lepidodendron, in coal-shale, from the Haughton Collieries.

3.—Two Specimens of Corals, from the drift at Norbury.

4.—A Specimen of Shale, from the Jet Amber Mine, Haughton, containing minute shells of Anthracosia.

5.—A Specimen of Shale, from the Peacock Mine, Hyde, containing beautiful markings of Ferns, (Pecopteris,) &c.

Presented by Mr. Butterworth, of Moor Side—

6.—Two Specimens of Aviculopecten papyraceus, from the Upper Foot-Mine, Oldham.

Presented by Mr. E. W. Binney—

7.—Specimens of Fossil Plants, from the Lower Permian or Astley Pebble Beds.

BOOKS, &c.

Presented by the Author, (Mr. E. W. Binney, F.R.S., F.G.S.)—

1.—Some Additional Observations on the Permian Beds of South Lancashire.

2.—A Paper, from the Quarterly Journal of the Geological Society, (London), "On some Fossil Plants showing structure, from the Lower Coal-measures of Lancashire," with illustrative diagrams.

PRESENTED BY THE AUTHORS—

3.—Proceedings of the Geologists' Association.

4.—Mining and Smelting Magazine.

5.—Journal of the Royal Dublin Society.

PRESENTED BY THE COUNCILS—

6.—Memoirs of the Literary and Philosophical Society of Manchester.

7.—Quarterly Journal of the Geological Society.

8.—Proceedings of the South Wales Institute of Mining Engineers.

9.—Transactions of the North of England Institute of Mining Engineers.

REPORT OF THE COUNCIL.

In resigning the office they have held during the last twelve months, your Council have much pleasure in being able to congratulate you on the continued prosperity of the Society. Twenty-one new ordinary members have been elected in the course of the session, and the losses have been very few from either death or resignation—the number being four of the former, and three of the latter.

A considerable number of valuable papers both on Geology and Mining have been read at the monthly meetings, showing, both in the fact of the papers being brought forward and in the discussions to which they gave rise, that a healthful spirit of enquiry exists among the members of the Society at large. It may be proper to add, that to the paper "On the Coal-strata of Lancashire," by the President, (Mr. Dickinson), is appended an extensive series of sections, which, though they added very materially to the amount of the Printers' bill, will, it is hoped, be found of great and permanent value to both the miners and landed proprietors of the country. A large number of extra copies of these sections having been struck off, they can be furnished at a moderate cost to the public, thus affording to persons who are interested in our coal-fields an opportunity of becoming possessed of a great amount of

accurate and important information, the result of the combined efforts, during many years, of several of the leading coal-proprietors in all parts of the district. When it is considered how liable the information respecting the details of the strata sunk through at any particular point is to be lost or thrown aside as useless, for want of any known bearing upon the details ascertained at other and distant points, it will at once be seen how great a service is performed by those who preserve such details; and also by any-one, who, having the opportunity, will be at the pains to collect and arrange them for the benefit of future explorers of the mineral treasures in a coal-field so difficult to trace from one extremity to the other, as the one which exists in Lancashire. The putting on record, in a permanent and available form, of information of this kind, will, it is not doubted, be looked upon as a full justification of your Council in incurring the extra expense with which it has been attended in the first instance.

Some valuable books have been added by purchase to the library. The Maps too of the Geological Survey of Great Britain, both on the one-inch and the six-inch scale, relating to this district, have been completed, so far as they are at present published.

An Excursion, on the 18th of August, was undertaken by some of the members of the Society to Matlock, to meet the members of the Dudley Geological Society and Field Club and their friends. A pleasant day was spent in examining the chief features of that interesting neighbourhood, and an account of the excursion will probably be laid before the Society at an early meeting in the ensuing session.

LIST OF NEW MEMBERS ELECTED IN THE SESSION 1862-63.

Mr. R. C. Webster, Ruabon Colliery, Ruabon.
Mr. John Stewart, Dunkenhalgh Park Colliery, near Accrington.
Mr. Richard Smith, Little Green, Collyhurst, Manchester.

Mr. F. R. Fairbank, M.R.C.S., St. Mary's Terrace, Hulme.
Mr. Thos. Pilkington, Woollen Manufacturer, Bury.
Mr. James Farrer, Surveyor, Bury.
Mr. Thomas Ashworth, Cheadle, Manchester.
Mr. Thomas Baldwin, Civil Engineer, Bury.
Mr. John Aitken, Bacup.
Mr. Samuel Wrigley Leach, Low Moor Colliery, Oldham.
Mr. George Nesbitt, 9, Piccadilly, Manchester.
Mr. John J. Atkinson, Inspector of Mines, Bowburn, Ferry Hill.
Mr. Thomas Woods, Kersal Lodge, Higher Broughton.
Mr. Henry Baines, Clifton and Kearsley Colliery, near Manchester.
Mr. Edward Young, St. David's Firebrick Works, Oughty Bridge, near Sheffield.
Mr. William Smethurst, Scott Lane Colliery, Blackrod, near Chorley, Lancashire.
Mr. Thomas Harrison, Mining Engineer, &c., Barnsley.
Mr. G. C. Greenwell, F.G.S., Mining Engineer, Poynton and Worth Collieries, near Stockport.
Mr. James Hibbert, Bardsley Colliery, Ashton-under-Lyne.
Mr. Spence, (Messrs. Butterworth & Brooks), Sunnyside near Haslingden.
Mr. Matthew Bennett, Moor Side House, Little Hulton, Bolton-le-Moors.

LIST OF MEMBERS WHO HAVE WITHDRAWN FROM THE SOCIETY IN 1862-63.

Mr. John Balderson, Junr.
Mr. H. Fishwick.
Mr. O. A. Ferris.

LIST OF MEMBERS WHO HAVE DIED DURING THE SESSION OF 1862-63.

Mr. James Dearden.
Mr. John Hadwin.
Mr. George Mosley.
Mr. Samuel Fletcher.

MANCHESTER GEOLOGICAL SOCIETY.

BALANCE SHEET, 1863.

Abstract of Receipts.

1862.		£	s.	d.	£	s.	d.
Sept. 30.	Balance brought down				83	3	6
	Subscriptions, 1862-63, 116	116	0	0			
	,, 1861-2, 3	3	0	0			
	,, Half-year, 1863, 4	2	0	0			
					121	0	0
	Compositions, 3				30	0	0
	Dividends on Stock				6	15	0
	Interest allowed by Bank				2	18	7
	Proceedings Sold				9	19	6
	Balance due to Treasurer				10	0	0
					£263	16	7

Abstract of Payments.

1863.		£	s.	d.
Oct.	Library	14	1	1
	Reports of Meetings	142	11	6
	Reporters	13	13	0
	Printing and Stationery	4	17	3
	Postages and Delivery of Circulars	24	10	11
	Furniture	5	10	0
	Gift to Mr. Parker for extra Services	5	5	0
	Collector's Commission	5	19	0
		216	7	9
1863.				
Oct.	Balance in the Bank	47	8	10
		£263	16	7

Examined and found correct, Oct. 19th, 1863.
JAMES HERTZ, Auditor.

HENRY M. ORMEROD, Treasurer.

The President—I think the meeting should know that during the past year we have elected twenty-one new members; and our loss by deaths and resignations is only seven, leaving a balance of fourteen gained to the Society. This shows that we continue to increase, as we have done for some years past, since the resuscitation of the Society.

Mr. James Hodgson, C.E., proposed—"That the reports and balance-sheet be adopted and printed for circulation among the members."

Mr. Peter Spence, F.C.S., seconded the motion, which was adopted unanimously.

It was then proposed by Mr. T. Farrimond, seconded by Mr. J. J. Horsfall, and passed,—"That the thanks of the Society be given to the respective donors to the Museum and the Library during the last Session."

The President—As you are aware, a certain number of the Council must resign each year. The four who have attended the fewest times must retire; and the two Vice-presidents who have attended the fewest times must also retire; all the others being eligible for re-election. The President also is only eligible for the office for a period of two years. Having myself had the honour of acting as President of the Society for the last two years, my term of office will now expire, as customary, at the termination of the present meeting. In addition to the four members of the Council whose times of attendance have been fewest, the active members of the Society have thought it desirable that not only four, but all, whose attendances are so few as to manifest a light interest in the management of the Society, should also be withdrawn, and gentlemen whose frequent attendance at the meetings have been such as to show that they take an active interest in its

proceedings, or who appeared likely to do so, should be elected. That is what the active members of your Council recommend to this meeting. They have given the matter very careful consideration, and have drawn up a list of names, which will be submitted to you.

Proposed by Mr. Jas. Hodgson, C.E., seconded by Mr. Peter Spence, F.C.S., and passed *nem. con.*

That the following Gentlemen be the office-bearers for the ensuing year: viz.—

President:

ANDREW KNOWLES, Esq.

Vice-Presidents:

E. W. BINNEY, F.R.S., F.G.S.,
SIR JAS. P. KAY-SHUTTLEWORTH, BART., F.G.S.
JOSEPH DICKINSON, F.G.S.
W. ROBY BARR, Esq.

Treasurer:

MR. HENRY MERE ORMEROD.

Auditors:

R. P. GREG, F.G.S. | MR. JAMES HERTZ.

Honorary Secretaries:

JOHN ATKINSON, F.G.S. | JOHN EDW. FORBES, F.G.S.

Honorary Curators:

MR. E. W. BINNEY, | MR. H. M. ORMEROD.

Other Members of the Council.

MR. THOMAS ASHWORTH,
MR. JOHN BRADBURY,
MR. JOSEPH CHATWOOD,
MR. JOHN CROSS,
MR. THOMAS FARRIMOND,
MR. JOSEPH GOODWIN,
MR. G. C. GREENWELL, F.G.S.,
MR. J. J. HORSFALL,
MR. CLEGG LIVESEY,
MR. GEORGE PEACE,
MR. JOHN TAYLOR,
MR. JOHN WILD,

And representatives of this Society at the Council Meetings of the Natural History Society,—Mr. E. W. Binney, and Mr. Alderman Harvey.

Mr. Binney, then said—There is one thing I should like to direct the attention of the meeting to, and that is the collection of more specimens. Our list of donations is not a very large one this year; and I should like very much to increase our Museum. We have only two or three donors of specimens. When we consider the great number of coal proprietors on our list as members, the list of donations is a very scanty one, and would seem to show that the bulk of the members feel little interest in geology. I should like to see our local collection largely increased, though I have no desire to see it made a little British Museum. Many gentlemen come and find we have scarcely any collection of Lancashire silurian fossils, when we ought to have the best in the country, as at Coniston and near Kendal there are plenty of materials. Of Lancashire carboniferous limestone fossils we have comparatively none. There are some magnificent specimens found near Ulverstone, but we have none of them here. We have a middling collection of the lower coal-measures, but not what we should have as a local collection. I should like to see more money spent on fossils, and less in printing, on which we have already spent a great deal. I should like to cut down the Reports, and spend more on the Museum and Library. As to what we ought to do, I am willing to some extent to make this a Mining Association. Mining gentlemen subscribe, and we are very glad of their money, but we should like to see them also come more among us at our meetings. We have held out all kinds of inducements for them, but have not succeeded in bringing them here as a body. I am glad to say we have able assistance from some few of them. I hope next year we shall have a better list of donations than we have had this year.

The President—As regards the Library, I am not aware that any book has not been added which any member has expressed a wish that we should have. Every book proposed by a member has been purchased. You have hit the coal proprietors rather hard, as they are the very gentlemen who generally form the majority of attendance at each meeting.

Mr. Binney—In reply, I have to say that we generally elected a number of coal proprietors on the Council. At our last annual meeting five of these gentlemen were put on, and they have all now to be taken off, because they did not attend one meeting. I think this strongly corroborates the view I have taken.

Mr. Hodgson—I would suggest that there should be no shortening of the Reports. They are very valuable, and reflect great credit on our Secretary. If we can get fossils for the Museum, and improvements in the Library, in addition to the Reports, so much the better, but do not curtail the reports of the meetings. Suppose we were to send circulars to the coal proprietors? Surely something may be done among them in regard to fossils. It cannot be for want of opportunity, or power, and if they were urged and desired to do all they could to get specimens for us, I think it would be done. I hope no attempt will be made to shorten the Reports. If they were a guinea each I think I should be inclined to buy them, I consider them so interesting.

Mr. A. Knowles (President elect)—As to the attendance of coal proprietors, I have been present at a number of the meetings of the North of England Institute of Mining Engineers, and I have always found them less fully attended than the meetings of our own Society, so that, although the members present at our meetings are not so numerous as we could wish them to be, we may congratulate ourselves they are what they are. With regard

to an increased collection of fossils, there is plenty of room in the Museum for them.

The President—We all know the active interest Mr. Binney takes in the Society. Perhaps he is too anxious to make us go quickly. I think during the last half dozen years, since we elected Mr. Binney as President, and adopted the principle of electing only those as officers whom we have found to take an active part in the Society, it has gone on increasing its members every year by twenties and thirties. For this reason I think we should be satisfied with the progress we make. It is quite right to spur the members up occasionally, but what has taken place is anything but discouraging.

Mr. Hodgson—I am connected with the Mechanics' Institute, in Liverpool, and my experience in connection with it shows me nothing will do but agitation. The Mechanics' Institution would have died years ago if it had not been for continually agitating—I may almost say, boring the public. If circulars, setting forth the objects of this Society, were printed, and circulated extensively, say, once a quarter, such a course might have a good effect in drawing the attention of gentlemen to it who would be glad to join it as members, and add to its Museum fossils collected in their respective localities.

The President—It was thought a bold step when we sent circulars out last year, and the year before, but the experiment proved very successful.

Mr. Binney—We are particularly obliged to Mr. Atkinson for the great trouble he has taken in getting up the Proceedings, and seeing them through the press. It is a kind of work which we could hardly expect any man to take for so many years. I wish,

therefore, to propose that the thanks of the Society be given to the Honorary Secretaries for the efficient manner in which they have performed their duties during the past year.

Mr. Hodgson—I was going to propose a vote of thanks to Mr. Atkinson, and I have therefore great pleasure in seconding the motion proposed by Mr. Binney. Considering the amount of labour connected with the reporting of the meetings, I have been much surprised at the excellent way in which it is done.

The President—I have great pleasure in putting the motion.

The resolution was passed unanimously.

Mr. Atkinson—As the Secretary present, I beg to return thanks for my colleague and myself for the vote of thanks given to us. Anything I have been able to do, has been done with great pleasure. I only wish my professional engagements gave me the opportunity of doing more than I do. However, what I am able to do in the way of assisting with the Reports, I shall be happy to continue to do. One thing I may be allowed to mention, relating partly to what Mr. Binney said in regard to specimens; it is a suggestion I wish to make about fossil specimens. The finder of a specimen, when he is not what is called a collector, perhaps considers it very curious, but asks himself, "What is the use of preserving a solitary curiosity?" Hence, when its novelty is worn off, it is generally thrown aside, broken, or lost. Now persons in this position should bear in mind that specimens of fossils attain their full value only when they are brought together, so as to form a series. Hundreds upon hundreds of specimens are no doubt thrown away in this county every year, from being looked upon individually as of no importance; but if they were preserved, and

brought to our Museum, to make up missing links in a series, they would become very valuable. I think this is a subject of great importance, and that the attention of our miners and geologists should be urgently drawn to it. Let them be careful of specimens, and have them sent to our Museum for examination. If they are found to be duplicates of what we already possess, they can be laid aside, and reserved for some young geologist who wishes to make up a collection; for geology is a science in which a learner can do nothing without the actual object of his study before him. It is for this reason that specimens which the advanced geologist might deem worthless are often useful to the learner. I trust, then, that we shall have more specimens collected, and brought or sent to the Museum. Their value could then be ascertained. Many valuable ones, even for the Museum, might be obtained in this way. When useless there, they could still be turned to excellent account by being used to enlarge the collections and encourage the labours of young geologists.

Mr. Binney—The subject of excursions has been mentioned in the Report. Last year we had no excursion, but we availed ourselves of the opportunity of joining the Dudley Society at Matlock. There is great difficulty in getting a sufficient number of members to join to make it worth while for the Secretary being at the trouble to go to a Railway Company and make the necessary arrangements. An excursion implies a great amount of trouble to officials. We have not had encouragement sufficient to propose any more excursions. The Dudley Society said they should be glad to join us in North Wales at Ruabon; the Liverpool Society is ready to meet us at Runcorn or Wigan; and the Yorkshire Society wish to meet us at other places; but we have not been able to give any reply, simply because our members do not

show interest enough to make it worth while. When we went to Matlock we were almost lost in the crowd; the Dudley Society numbered eighty or ninety, and we had only five at the end, and not more than ten or eleven at the beginning. (Laughter.) We might have excursions in the winter months in the district around Manchester. I should be happy to go round the district with others. I have known gentlemen who have been members of the Society for twenty years, and who have never been round the outside of the town. I think, during the ensuing session, we might discuss the geology of the immediate district, and go around and look at it. Another subject has been suggested to me—that we should investigate fire-damp, and the power of standard gauze to prevent the passage of flame through it. It is suggested that we should make a series of experiments on fire-damp, and try how the gas could be fired through the gauze. There have been many experiments made, but the subject is not by any means exhausted. If we make such investigations we should have the assistance of some chemical gentlemen. I should like to see the gas we experimented upon first analysed, because the experiments, however carefully made, would prove of no use if our premises were bad.

A long conversation then ensued—participated in by several of the members present—on fire-damp, safety-lamps, &c., and on the desirableness of adopting Mr. Binney's suggestion relating to these subjects. It was finally agreed that it should be left to the Council of the Society to appoint a committee and to take such other measures as seemed best to them for securing a series of experiments on "safety-lamps," as they are called, and on the gases in coal-mines.

Mr. Smith—In regard to the prosperity of the Society, I think it is not a time to rest and be thankful while we have an attendance of less than twenty. There are several persons in the district fond of

the study of geology, who have an idea that the Society has become altogether a Mining Association. It should be remembered that its original object was that of a Geological Society, as well as a Mining Association. If excursions were arranged, and time given beforehand, there would be a chance of getting a better attendance. The last time I only got my circular two days before the excursion, and consequently was unable to make arrangements to join it. In a society like this we ought to be able to get twenty or thirty members ready to take part in these excursions.

The President—In regard to geological subjects, I have noticed that we have not the attendance that we have when a mining subject is brought forward. I do not think we have a dozen pure geologists in the Society. Most of the members are connected with mines.

Mr. Atkinson—Mr. Smith seems to have an idea that the Society has dwindled into a Mining Institute. During the last session fourteen papers were read, and ten out of the fourteen were geological papers. I concur in the suggestion that it is desirable that many of our members should make themselves better acquainted with the geology of the district round Manchester, as it is a very interesting district. I have gone round it with Mr. Binney, many years ago. If we arrange distant excursions the members will not attend; they cannot always afford the time. If we took these local excursions, as Mr. Binney suggests, more members would probably join in them, and they could not fail to be both interesting and useful to young members. It is quite a mistaken idea for members and the public to entertain that this has ceased to be a Geological Society.

Mr. Binney—I concur with much that Mr. Smith, that you, Mr. President, and that Mr. Atkinson have said. I, as a geologist,

come here and give two hours of my time on a Tuesday, and this at an hour when gentlemen in Manchester cannot well leave their business. Few of the geologists of Manchester can come here, unless they come at night. We give our time in the middle of the day to get country members and coal proprietors to come. There is a good deal of truth in the alleged preponderance of mining subjects in the Society.

The President—Does anyone think a more convenient time can be fixed for holding the meetings? We have tried evening meetings, and could not get anyone to attend them. We have tried other days, and it is found that the present hour has brought us a larger number of members than any other.

Mr. Goodwin—Mining subjects have brought us as many as sixty-four members to a meeting, and often more than forty; whilst geological subjects only bring thirteen or fourteen. I take an equal interest in geological as in mining matters. The hint that Mr. Binney has given for us to take a stroll round the town is a good one. I could afford any Saturday afternoon, and I think it would be a suitable time. I cannot devote a whole day to an excursion.

Mr. Dickinson then resigned the chair, which was taken by Mr. A. Knowles, the President elect.

Mr. Binney—I beg leave to move a vote of thanks to Mr. Dickinson not only for his services to-day, but for his services as President during the two past years. We have all reason to be thankful to him for the great interest he has evinced in the proceedings of the Society, and the great attention he has given to the duties of his office. Though I have stated that I should like

this to be a Geological Society as much as a Mining Society, and he takes the opposite view, yet I know he has the interests of the Society as much at heart as I have.

Mr. Smith—I have great pleasure in seconding the resolution, for I believe the late President has been most zealous in promoting the welfare of the Society.

The resolution was carried unanimously.

Mr. Dickinson—I am much obliged to you for the thanks you have given me. In common with others, I have done my best for the welfare of the Society; and it has been the object of the Committee to import into the Council those who showed the greatest interest in it, so as to bring their services into active operation. With good active members and good papers it must succeed. If mining subjects have taken the precedence for the time, it is simply because the mining members have been the most active. I certainly think that for the past few years they have been the most active, and that the papers they have brought forward have proved the most interesting papers on both subjects. The two subjects are intimately connected, and I am glad to see that we are all working with the same object; also that you have elected as President a gentleman who is so largely interested in the mines of this county.

Mr. Atkinson—We shall not have done our duty to the Society, and to the members of the Council, if we do not propose and carry a vote of thanks to the Vice-presidents and other officers of the Society. I must say, with regard to our late President, and senior Vice-president, Mr. Binney, that the Society is much indebted to them for its prosperous condition. Since I became a

member I have seen a good deal of the way in which our affairs have been managed, and I do not hesitate to say that these two gentlemen have been the life and soul of the Society. I can say this without any desire to depreciate the services rendered by other members. I beg to propose a vote of thanks to Mr. Binney and to the retiring members of the Council for their services during the year.

Mr. Peter Spence seconded the motion, which passed unanimously.

This closed the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 11.] VOL. IV. [Session 1863-64.

The First Ordinary Meeting of the Session was held in the Museum, Peter Street, on Tuesday, November 24th, 1863.

MR. ANDREW KNOWLES, the newly elected Pesident, occupied the Chair.

The President—Before proceeding with the usual business of our meeting, I beg to take this opportunity of thanking you for the honour you have conferred upon me in electing me to be your President. I fully estimate the importance of the trust you have placed in my hands, and all I can say is that I shall endeavour to the best of my ability to promote the true interests of the Society.

Mr. H. Baines presented two Silicious Stones, which he said were found in the Trencherbone Mine, on the Clifton estate. He believes that several of these specimens were to be found in the neighbourhood of Oldham. One of the specimens he had presented, weighed 38lbs. when it was first found, but it had been broken. The other weighed about 15lbs.

Mr. R. A. Eskrigge presented to the Society some specimens taken from the lower silurian formation on the Llandeilo flags.

Mr. Binney said he wished to impress upon the members the importance of placing in the Museum as many Lancashire silurian fossils as could be procured. In the neighbourhood of Ulverston, and beyond Kendal, there were some very fine specimens, which were well worth looking after.

Mr. Wild presented to the Society a specimen of *Calamites*, showing the mark of one branch only at each joint alternately on the right and left side.

Mr. E. Hull said he was of opinion that the specimens given by Mr. Baines looked very much like gannister, and that in his experience the lower-coal formation was not conformable with the upper.

Mr. Dickinson—These specimens from Clifton are identical with those produced in large quantities from the Roger Mine, Ashton-under-Lyne; and also from the Black Mine, at Oldham. They appear to me to be aggregations of silica. As to what Mr. Hull has said, I have seen some nearly flat sides or faults which might give a person an idea that the lower coal-measures are not conformable with the upper; but of all the examinations which I have made myself, I have invariably found the lower coal-measures of Lancashire conformable with the upper.

Mr. Hull—I grant this is generally the case; but I know a section near Bury which is a decided exception. The section to which I refer is shewn in a quarry at Higher Wood Hill, on the right bank of the river, a short distance north of Bury. There the shales which underlie the Arley Mine are clearly seen to repose against the denuded edges of the flagstones of the lower coal-measures. I have described and given a drawing of this

section in the memoir "On the Geology of Bolton-le-Moors," to which I must refer for a fuller description.

Mr. Binney—What Mr. Dickinson has stated I know is generally the rule: but if there is an exception we ought to go and look for it. One good fact of this sort is worth fifty hypotheses; and before we pass any judgment upon such a subject we ought to have ocular demonstration of the fact.

Mr. Hull—I should be happy to escort the members to the place.

Mr. J. Atkinson said he was not quite sure that Mr. Baines's specimens were not boulders.

Mr. Hull—You will notice that there is a distinct line of lamination.

Mr. Dickinson—I do not think the fact of lamination is a proof that it is a boulder. An aggregation may have lamination as well as a stratum.

Mr. Baldwin, of Bury, presented some fossils taken from the drift gravel, near Bury; they were specimens of *Aviculopecten*.

Mr. Fairbank exhibited six Flint Arrow-heads, from Canada, and read the following communication—

ON SOME FLINT ARROW-HEADS, FROM CANADA,

BY

F. R. Fairbank, L.R.C.P., F.A.S.L., &c.

The arrow-heads presented for inspection, were ploughed up in one of the valleys on the shores of Lake Erie, Canada. They were

found lying in the mould a few inches from the surface, and appeared to have been covered by sediment washed by the rain, and by the overflowing of a small stream, from the sides of the hills skirting the valley. Similar implements are found scattered over most of the valleys in that locality. It is believed that they were formed and used by the Eries, a tribe of Indians, who, numerous in 1623 when visited by Father Joseph de la Roche d'Allyon, were exterminated in less than 30 years from that date, by constant and sanguinary strife with their kinsmen the Hurons, Petuns, and Neuters, and also with the powerful Iroquois their common enemy. We need not, then, be surprised that the weapons which they used are found in great numbers.

The arrow-heads may be divided according to their shape into three classes.

1st. Almond shapod. $1\frac{1}{2}$ inches long, $\frac{7}{8}$ inch broad, and $\frac{1}{4}$ inch thick. The whole circumference sharp and serrated

2nd. Triangular. $2\frac{1}{8}$ inches long, $1\frac{1}{8}$ inches broad at the base, and $\frac{1}{4}$ inch thick. The base of this head is sharp and serrated like the sides. Its angles project slightly beyond its centre, so as to make this edge slightly crescentic.

3rd. In this class a process extends backwards from the centre of the base. The basial angles, also, extend slightly backwards. The heads of this class vary in size, the largest exhibited is 3 inches long, $1\frac{3}{8}$ inches broad, and $\frac{1}{2}$ inch thick.

The first class resembles, in general characters, the implements found in the drift, known as "Langues des chats." The second class, besides making a good arrow-head, would, if fastened by its apex into the end of a staff at right angles, make a very useful hatchet. This instrument is very carefully made, and must have required considerable dexterity in its formation, as it is unusually thin for its size. The basial process in number three would enable the head to be more firmly fixed to the shaft. The projecting posterior angles would prevent the arrow being drawn out,

when it had pierced the body. Most of this class are slightly curved, probably from the conchoidal fracture of the flint. One of them possesses a double twist. Thinking that this was artificially produced to give the arrow a rotatory motion during its flight, I formed an arrow with a head similar to this; and found that the curve was sufficient to produce rotation during its passage through the air. This movement did not occur when the head was straightened.

It is interesting to compare these implements with those obtained from the drift. Though in some respects they are superior to the latter, their general character is the same. Like the drift implements they are rough hewn, and exhibit no signs of friction. The makers of them may therefore be considered to have been much on a par with people inhabiting Europe during early and middle *Stone-age*.

The thanks of the meeting were given to Mr. Fairbank for his communication.

Votes of thanks were then unanimously given to the gentlemen who had presented specimens.

Mr. George Wild then presented a model of a safety sinking Capstan and Hoist-Hook, and read the following paper.—

ON A SINKING CAPSTAN, OR HOIST-HOOK,

NOW IN USE AT THE BARDSLEY COLLIERY, ASHTON-UNDER-LYNE, BELONGING TO MESSRS. S. WILD & Co.

BY MR. GEORGE WILD.

I have great pleasure in presenting to the Society a model of a Sinking Capstan or Hoist-Hook now in use at the Bardsley

Colliery, Ashton-under-Lyne, belonging to Messrs. S. Wild & Co. The hook has been in use whilst sinking the Victoria Shaft from the Peacock to the New Mine, (which was found at the depth of 560 yards, the distance between being about 80 yards), and is as safe and perfect as when it left the hands of the blacksmith. It is being used in sinking the Diamond shaft. I have long felt desirous to have a good and safe hook, and to all appearance the present one presents features which recommend it, not only for safety but great strength and durability, also great ease in attaching and detaching, whilst at the same time it is next to impossible it could become disengaged by accident.

As the Society is the most proper channel through which to make known any improvement in apparatus for the safer working of collieries, I shall leave it (the Society permitting) in its hands; where, from the great practical experience of many of its members, no doubt a proper verdict will be given of its merits or demerits; and should it be found to be an improvement, advantage may be taken of it by the members, and through the Society, the public generally.

Hoping it may be the means of averting some of the frightful accidents to which the sinking of collieries seems yet liable, I will now proceed to describe it by means of the drawings.

DESCRIPTION OF THE SAFETY HOOK.

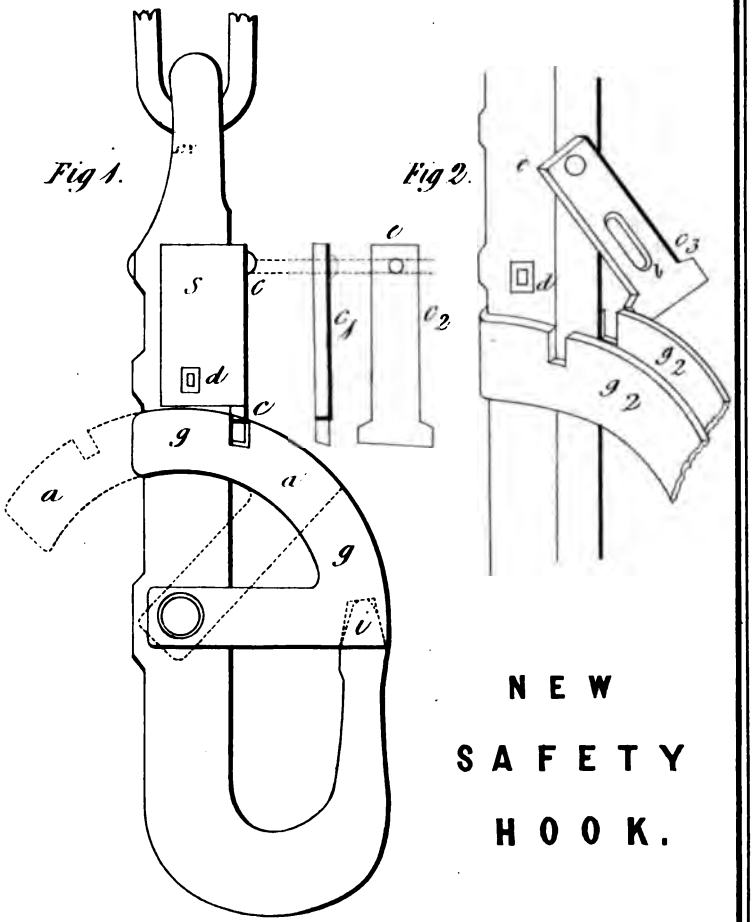
Fig. 1.—A side view of the hook with the guard on.

g—A double guard to prevent the hook from getting disengaged, whilst it strengthens it by admitting its point, *i*. The guard is made purposely bulky, that the loop may not climb to some dangerous position.

c—The catch partly concealed behind the spring, *s*.

c_1—The catch in its former edgewise position, but removed from behind the spring.

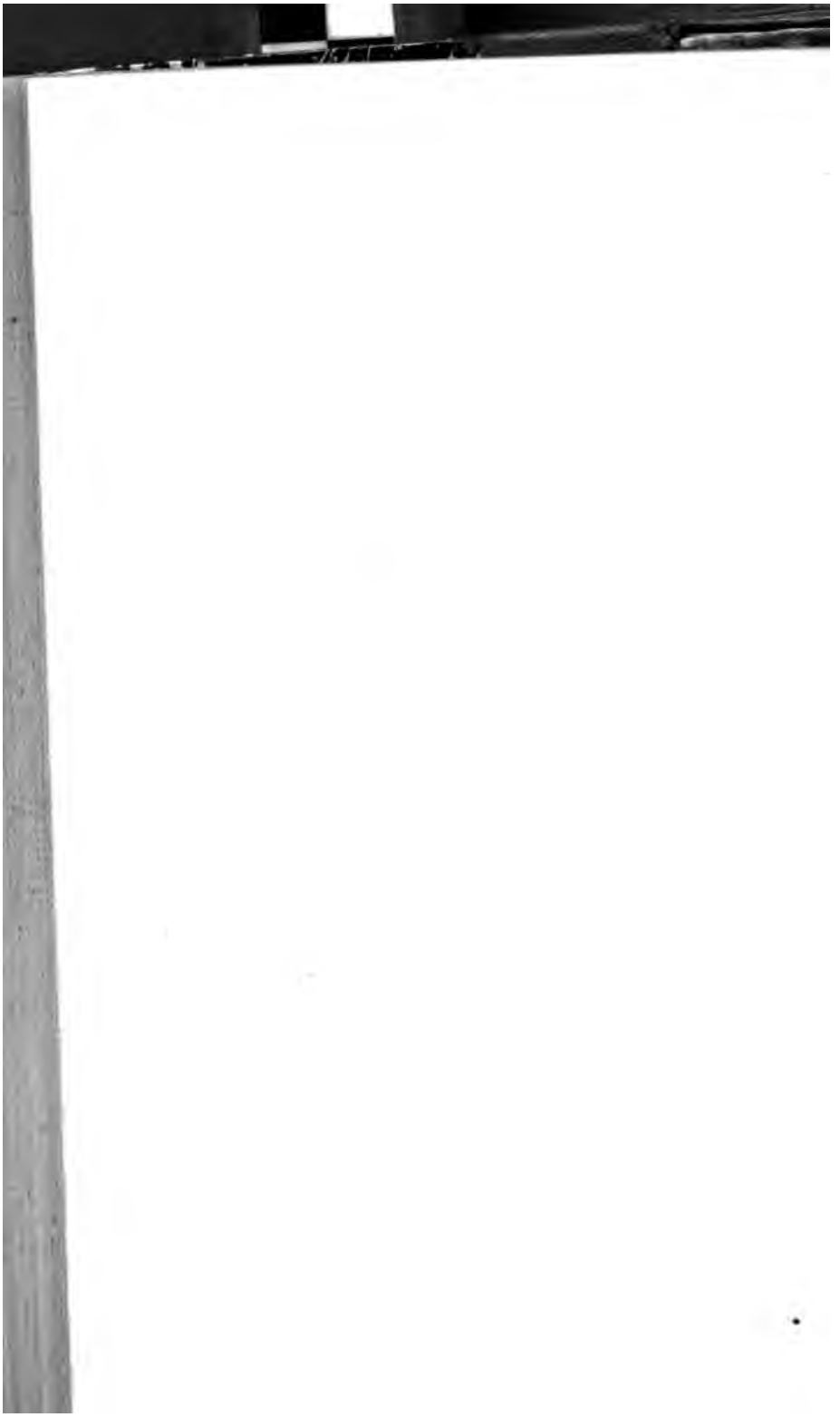
c_2—Side view of the catch.



NEW SAFETY HOOK.

BY Mr GEO. WILD.

Bardsley Colliery. Ashton-under-Lyne.



b—A depression for the thumb in opening the catch, *c*.

s—A thin plate of spring-steel, firmly bolted at its lower end to the shank of the hook, at *d*, the upper end being free to move in the direction *from* the hook against which it rests.

N.B.—The spring *s* acts in regard to the catch *c* (at *e*) exactly in the same manner that the backspring of a common clasp-knife acts in regard to the blade. When the catch is *open* it stands in the position of the blade of a clasp-knife *half open*.

Fig. 2.—An oblique view of part of the hook, with the spring [*s*, Fig. 1] removed, showing the position of the catch c_3 when partly open; and showing likewise, at g_2, the two branches of the double guard, and the way in which the catch passes across them to secure the guard upon the point of the hook, at *i*, Fig. 1.

As a capstan hook it will be found very safe for threading through the intricate mazes of horse-trees and collarings, having no catching points.

Mr. Wild concluded by presenting the Model of the Safety Hook to the Society, for exhibition in its Museum.

The thanks of the Society were unanimously voted to Mr. Wild for his valuable contribution.

Mr. Dickinson—It is very desirable that we should get a number of models in our Museum. Such a collection would be of the utmost practical value. My experience is that our Museums in this respect, are far behind those on the Continent.

Mr. Binney—Yes: there the Government lends a little help, but here we have none.

The President said Mr. Binney had a communication to make to the Society.

Mr. Binney—Some 24 years ago I was Secretary to this Society with Mr. Thos. Ashworth; and the Council then thought they should like to get some information from coal proprietors. Accordingly, I, by the direction of the Council, sent out 250 circulars; and after waiting a long time for the answers I only received one reply, and that was from the late Mr. Ralph Thicknesse, M.P., of Wigan. And although at the time I did not like to bring the fact before the public, I do think now, after the lapse of 24 years, it would be well really to bring the matter before the Society. I therefore propose to read the circular which I sent, and the queries, together with the replies I received to them. It will be seen what kind of information we then wanted. We do not seek an enormous amount of information; nothing in fact to what the mining gentlemen of the north give of their own free will at the present time. If we sent such questions as they we should probably get no answers at all.

This is the circular.

Manchester, July 20, 1839.

We are directed by the Council of the Manchester Geological Society, to request the favour of your furnishing them with copies of any notes, of measures gone through in shaft-sinkings, particulars of borings, and plans of workings, which you may have in your possession.

Being convinced that much valuable information has been lost to the Coal owners of this and the adjoining Counties owing to the want of a place for the reception of the documents above alluded to, the Society has determined to form a *Depository of Mining Records, relating to the Lancashire and Cheshire Coal-Fields;* such depository to be kept at the rooms, of the Society, 29, Faulkner Street, Manchester, and to be open to the inspection of members, parties furnishing records, and gentlemen introduced by members. As a collection of sound practical information, conveniently arranged for reference, and readily accessible cannot but be of the greatest benefit to the mining interests, the

Council trusts that the proprietors of Collieries will do all in their power to assist in the formation of a registry of well ascertained facts, which shall not only be of value to the neighbouring Country, but of service to the nation at large.

The Council will feel further obliged by receiving answers to the accompanying series of questions, signed by the Proprietor or Overlooker of the mine, and by the presentation of any fossil organic remains, with the names of the places where found, for their Museum, which is intended to be gratuitously open to the public.

We are, Sir,
Your obedient Servants,

THOMAS ASHWORTH,
EDWARD WILLIAM BINNEY, } Hon. Secs.

P.S.—All communications to be addressed to the Secretaries of the Manchester Geological Society, 29, Faulkner Street, Manchester.

I received the following reply from Mr. Ralph Thicknesse, of Wigan.

Southport, August 28, 1841.

My Dear Sir,

At length I enclose answers to your questions, and if any explanation is wanted will endeavour to supply it without a very *long delay*. The insertion of the account of a Coroner's Inquest called forth a letter from our manager, Mr. Atherton, and I enclose both attack and defence. For the former there was *a reason;* and you will think for the latter also.*

Yours very truly,
R. THICKNESSE, Jun.

The following are the questions referred to, with Mr. Thicknesse's reply appended to each of the first twelve.

1.—The name and locality of the colliery?

Reply. Kirkless in the townships of Ince and Aspul.

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* See the account of the Coroner's Inquest and Mr. Atherton's letter, referred to by Mr. Thicknesse, and printed at the end of the queries and answers.

2.—The names of the owner of the land, and the present occupier of the colliery?

Reply. Owners Sir R. H. Leigh, Mr. Hodson, Mr. Woods; occupier Mr. Thicknesse.

3.—The number, names and descriptions of the seams of coal and other minerals it contains?

Reply. Cannel and King coal are both raised. The former the highest workable seam. The usual Arley Mines (Ravin, Yard Coal, Smiths' Coal, Arley Mine) are under the King Coal; as proved by a pit sunk in lands adjoining, from King Coal to Arley Mine, by Woodcock and Haliburton.

4.—The number and description of the beds or layers of each seam and their respective cleavages?

Reply. The Cannel about 3 feet thick, in one seam. The King Coal in two seams; one about 2 ft., the other about 1 ft. 6 in. to 1 ft. 10 in. The earth between these two varies from 2 ft. to 3 ft. 6 in. The face of the coal lies from S.W. to N.E. The face-sheds of the cannel in the same direction.

N.B.—Cannel being in blocks, surrounded by white scale, has end-sheds as well as face-sheds. The face-sheds are much more continuous and regular. The scale is also thicker in the face-sheds.—Say in the latter 1-16 of an inch.

5.—The thickness and quality of the several seams of coal; which of them have been worked—to what extent, and why the working of any of them has been discontinued or not commenced?

Reply. Cannel and King Coal, both of best quality. Cannel nearly all worked.

6.—The system of working?

Reply. Drifts.

7.—The amount of inclination, and direction of the dip of the strata?

Reply. Inclination about 1 in 20. Dip to the east.

8.—The direction, character and extent of the faults and the materials they contain?

Reply. Direction, N.W. to S.E. There are several faults,—the principal one a throw-down to S.W. of about 300 yards, none of the others exceed 40 yards. These faults are not every one of them to be described as a fault, but some rather as a series of faults succeeding each other in the same direction. The materials, when cut into, which is not often, are found to consist of fragments of the adjoining strata.

9.—The amount of steam or other power employed in lifting water from the mine, the depth of the pumping, its diameter, and the number of gallons of water raised per hour?

Reply. A steam engine with 13 in. cylinder; raises about 2800 gallons per hour. 100 Yards.

10.—The number of shafts and their diameters and depths?

Reply. Six coal-pits in use besides the engine-pit, whence no coal is raised. Many cannel-pits, but only one at present used.

11.—Accidents by explosion, and whether they occurred when the Davy was used or not?

Reply. Three in 25 years, as per Mr. Atherton's letter, which see.

12.—What other accidents have occurred at the colliery, and their causes?

Reply. The principal cause of accidents is from the falling of the top coal, or metal between the coals, when the colliers are not careful to prop them, or work under too far before they wedge them down.

13.—The system of ventilation practised? *No Reply.*

14.—General observations. *None sent.*

CORONER'S INQUEST.—An inquest was held on Saturday last, before J. Rogerson, Esq., coroner of this borough, touching the death of James Moulds, who came by his death from injuries received while working at the Kirkless Colliery, on the 30th ult., under the circumstances as stated in the following testimony:—Joseph Simpkin said, that he and deceased went down to their work between five and six in the afternoon on the day above named, and that the explosion took place about eight o'clock, in consequence of the deceased having placed his lighted candle against the wall, and going up one of the passages to drive out the air; that they have no safety-lamps, although they have had to run several times before to escape being burnt. There is no fireman kept about the works, nor any one employed to look after the ventilation of the Colliery. The deceased, after the accident, had to remain in the pit till after eleven o'clock, there being no person in attendance at the mouth of the pit, to wind him up until that hour. He died on the day previous to the inquest.—The jury expressed their astonishment, that the managers should neither provide the men with lamps when working in such dangerous places, nor have some person upon the ground during the night, to wind up the men in case of accident. Verdict—Accidental death.

To the Editor of the Wigan Gazette.

SIR,—On looking over a paragraph in your paper of Friday last, headed "Coroner's Inquest," touching the death of James Moulds, who was accidently burnt in one of the pits of Kirkless Colliery, on the night of the 30th ult., I

perceive much misrepresentation has gone abroad, from the evidence of Joseph Simpkin, who was examined before the Coroner's jury; and in defence of the managers of that concern, feel called upon to trouble you with the facts of the case, which I shall be obliged by your inserting in the next GAZETTE.

On the day in question, July the 30th, Moulds and Simpkin applied to the underground manager of the pit in which they worked, for permission to make a night-turn, in order to complete some scorage in their coal, that they might get paid for it on the following day. He expressed some surprise at such an application, as they had been idling through the day: but after some little hesitation, consented, and when the day-turn left off work, Simpkin, his brother (a boy), and Moulds, descended, as was expected with the intention of going to their own places of work: but, instead of this, with the design of "robbing" some coals which had slipped from a pillar side, and being paid for them as coals got from their own places, they entered some old workings, from which the rails had been a long time taken up, the current of air diverted, and the road or passage to them closed by a door set for the purpose; and after they had succeeded in carrying out a few tubs of rusty coal, which was evidence complete against them, for coal sent from their own drifts would have been quite black, the explosion took place in the absence of the two Simpkins, who were gone to the pit shaft, and consequently poor Moulds met with the accident which cost him his life, as his pick, cap, and remains of a candle, found upon the spot, by several men, who descended *immediately* afterwards, clearly testified. It seems unfortunate, that the evidence of these men was not required at the Coroner's inquest, and that the jury should have separated under the impressions stated in your paper, without a full investigation of the case. Had the matter been enquired into it would have been sufficiently proved, that every part of the workings, to which the men were appointed, and ordered to work, was perfectly safe. If the general state of the pit had been dangerous, the Simpkins could not have escaped; but, as before stated, the danger was confined to one particular part of the mine, where the men had no business to enter. Simpkin, in his evidence, further says, that there is no fireman, or person to look after the ventilation of the colliery, and no safety-lamps, and that Moulds had to wait until eleven o'clock before he could be wound up from the mine. In answer to this: there is a large fire-grate or furnace, constantly burning at the bottom of the pit, in order to produce a brisk circulation of air, and a man appointed to attend to it every day in the week; and several persons employed upon day wages, attend regularly to the ventilation, and to keep the air in its proper course. With regard to safety-lamps, they are always provided when required, but are certainly not often used, except in exploring old workings, making air courses through them, &c., because every part of the mine in which the colliers are employed, is made perfectly safe to be worked by candles; and in no instance of a "fresh engagement" is a workman permitted to commence operations before a lighted candle is placed in the drift he is appointed to. With respect to Simpkin's evidence of the delay between the time of the accident, and the time Moulds was wound up to the pit bank, it is in strict keeping with his other assertions. He states eleven o'clock as the time Moulds was got up from the pit; when, in reality, he had walked home, and I had despatched a messenger for a surgeon to attend him at ten o'clock. It has invariably been the proprietor's wish, that every thing should be made convenient and safe for the workmen; and no expense has been spared to render it so; consequently few accidents have occurred, considering the great number of hands employed, as for a period of nearly twenty-five years, during which time I have been connected with the management, only two lives (exclusive of the present accident), have been lost by fire-damp; and one of these was caused by a father forcing his son, a boy, into a drift, from which he well knew the air had been

excluded. I further feel thankful in being able to say, that there has not been a single life lost, for the same length of time here, by the failure of ropes or chains, during the times of the workpeople ascending or descending the pits.

I remain, Sir,
Your most obedient Servant,
JOHN ATHERTON.

Kirkless Colliery, Aug. 17, 1841.

The President—One thing we gather from these old documents, is that at the time they were written you connected mining with geology, in the proceedings of the Society.

A vote of thanks was passed to Mr. Binney for introducing the subject.

Mr. Hull—I think there are some questions in this circular that the coal proprietors of the present day would hardly consider pertinent; but there are other questions such as relate to details of sinkings and borings in the different strata of the mines, &c., of which it would be useful to keep memorials. Details as to the practical workings of collieries, would be hardly necessary I think. I must, however, in justice add, that in the whole coal-field I have scarcely found more than one refusal to give information necessary for the completion of the Geological Survey.

Mr. Chatwood—It is but natural that there should be a little difficulty in getting information out of a colliery proprietor, because in some cases secrecy is his property.

Mr. Binney—We do not want unnecessary information. In the north of England they publish everything connected with the place, and things we really should not have the audacity to ask for here.

Mr. Dickinson—I think there are many questions in th circular which the coal owners would not answer, I don't think th Society should put itself in a position to be refused. The sam grumbling is heard in the north of England, and at the la meeting that was held, Mr. Nicholas Wood complained that th coal owners did not give that Society the support it was entitle to. They give more information there, as Mr. Binney has said but it is because the collieries generally occupy a large tract country, almost by the square mile, instead of by the acre as her Here there are many small colliers who just supply th neighbourhood They have no other customers, and this make them chary to supply such information as may bring in a com petitor to injure their trade. If a few of the questions in thi circular were weeded out, the rest might be productive of som good.

Mr. Binney—I merely bring this forward now to be put int our proceedings out of respect to Mr. Thicknesse's memory, an to show the course the Society adopted many years ago, and leav the suggestion as to the future open.

The proceedings then terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 12.] VOL. IV. [Session 1863-64.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, December 22nd, 1863.

MR. ANDREW KNOWLES, the President, in the Chair.

Mr J. Wild presented a fine fossil calamite branch, taken from the Blenfire rock, near Oldham.

The thanks of the Society were unanimously voted to Mr. Wild.

Mr. Binney presented several specimens Mr. Parker had received from Mr. Grindley, of the Isle of Man, and read the following descriptive letter which accompanied them :—

ISLE OF MAN, DECEMBER 16th, 1863.

Dear Sir,

I have been expecting to hear from you every post, for months past; and I am, to tell the truth, very much surprised that you have not written. I trust

your silence arises from nothing more than mere neglect, and that nothing serious has happened to you.

Since I wrote to you, I have been corresponding with several parties about the impressions on the Laxey slates; and, among the rest, with Mr. Salter and the Rev. Mr. Brodie, of Warwick. Mr. Salter (from my description *only*) thought they might be double annelide burrows; but this is out of the question, as they have no connection with each other, and, therefore, cannot be *double* burrows. Further, their *depth* is insignificant when compared with their length (the diameter of their surface), and, therefore, they cannot be *worm* burrows at all. As I have just said to Mr. Brodie, if they are burrows at all (a supposition at variance with the fact of their occurrence *in pairs*), they may, perhaps, be burrows of some crustacean. Mr. Salter, also, recommended me to send slabs to the London and Manchester Societies, where he said they would get a thorough examination.

I sent Mr. Brodie some good specimens to exhibit to the western Geologists, and I have asked him to exhibit them to the London Society, and read a paper about them; I have not got any answer to this request yet. At Manchester you have had some good specimens before you for months, and have, I suppose, long before this, passed your verdict upon them.

Will you kindly tell me what that verdict is? As their discoverer, I am naturally anxious to know the opinion of your Society upon them; and as you have several very good Geologists among you, that opinion is of very considerable value. If you will also inform me whether you read my paper on these imprints to the Society, and, also, what has become of my paper on the Glossop drift, which Mr. Taylor said he gave in to the Secretary, I shall be obliged. I have not done much "Geology" lately, but I have come across one or two good sections of the drift; one in the glen here, which shows in its upper strata, several thin layers of peat, alternating with marine sand, &c.,—sure evidence of oscillations of sea-level within comparatively recent times. On this account I regard this as a very interesting section. Another good section, in fact the best I have seen in the island yet, occurs at Douglas Head, between the lighthouse and Fort Ann, where extensive excavations are being made for the new breakwater; Mr. Clague and I went over there a week or two ago, and I intend to go over there again more carefully, the first opportunity. In this section the whole series of drift beds may be traced; and what more interested me was, that *the beds occur in exactly the same order as they do about Glossop*,—till, with sand and gravel, both above and below. The main difference was, that while in the Glossop drift the

gravel was mainly of sandstone from the neighbouring rocks, in the Douglas drift it was principally of slate, with numerous pebbles of quartz and granite. What would the advocates of a cataclysm say to this? I am the more confirmed in my old opinion, that when we come to know the drifts better, we shall find it as orderly a deposit as any that went before or came after it.

* * * * * *

I remain,
Faithfully yours,
THOMAS GRINDLEY.

MR. PARKER,
MANCHESTER.

Mr. Atkinson, the Secretary, stated that he had never, till now, heard anything of the paper referred to in the letter.

The thanks of the Society were unanimously voted to Mr. Grindley, for his contributions.

Mr. James Heywood, F.R.S.—Before we enter upon the stated business of the day, I should like to mention to the Society, a way that has been invented for popularizing scientific matters before audiences. In London there is a Working Men's Educational Union, 25, King William-street,—and they have taken Chamber's Geology as their basis, and printed upon large pieces of calico the chief Geological illustrations. They are printed on a very large scale and coloured, and are accompanied by sections of the earth's crust, &c. Altogether this is adapted for popularizing Geology in a more decided manner than ever I have seen before. This adaptation of calico, and calico printing, to the purposes of science, is very valuable, and, in my opinion, admits of even a much wider use. It is a very effective method of teaching large audiences, and Chamber's work is, no doubt, a very good authority to go upon.

Mr. Binney said the Society possessed some of these drawings.

Mr Hull in concurring in Mr. Heywood's views, said, the advantages of these prints were that they did not tear, and cheaper than mounted paper.

The President said the drawings would be most valuabl illustrating the papers read before the Society.

Mr. Binney—We have no chance of popular lectures here. have neither room nor lights.

Mr. Plant said he had used these drawings for five years ir Geological classes; but the illustrations of Geological subjects given in a very broad manner, and were only effective when lo at from a distance. They were, however, capable of n improvement.

Mr. Atkinson said that nothing but the actual examinatio specimens themselves would make a person a real Geologist.

A paper was then read—

ON THE

OCCURRENCE OF GLACIAL STRIATIONS ON THE SURFACE OF BIDSTON HILL, NEAR BIRKENHEA

BY EDWARD HULL, B.A,, F.G.S.

It may not be uninteresting to the members of this Society, communicate some cases of glacial striations which have l come under my notice, but of which no account has yet l published; before doing so, however, I may be allowed to r briefly to those which have already been described.

Two remarkable instances in which the surface of the New Sandstone, at Liverpool, has been observed to be planed d and marked by parallel groovings and furrows, have been

cribed by Mr. G. H. Morton, F.G.S., in the Journal of the Geological Society of London.* In company with this gentleman, I visited these spots during the Summer before last, and was greatly struck by the freshness and regularity of the striations. The finest example occurs south-west of Kirkdale jail. The surface had, within the last few years, been bared of its covering of boulder clay, which had served as a protection to the glacial markings. The direction of the great majority of the striæ, as seen over a surface of nearly an acre, is N. 10° W.; but there are a small number of cross groovings pointing east.

The second instance occurs about a quarter of a mile south of the latter, in a field near the north end of Gore-street; the striations are cut on a boss of hard grit, and point northwards; these are on the north-side of the town, at a height of 65 feet above the sea-level.

The third case, at the south side of the town, is in a field north of Park Hill House. I fear these are irrecoverably lost, as I visited the spot, in company with Professor Ramsey, F.R.S., only a few weeks since, and the spot was being rapidly converted into sites for buildings. The striæ were cut on a surface of hard red sandstone, —the larger number pointed N.N.W.; but there were here, also, a few sharp cuts crossing transversely from west to east. The level of this spot, according to Mr. Morton, is 120 feet above the sea.†

The fourth instance which has come under my notice, occurs on Bidston Hill, on the west side of the Mersey, and at an elevation of probably 150 feet above the sea. These striations were noticed many years ago, by Mr. J. Cunningham, F.G.S., of Liverpool, who also assures me that he had long since noticed those on the opposite

* Vol. 18, p. 377.—A description of these cases is also given by Mr. Morton, in his Memoir, "On the Geology of the country around Liverpool," p. 40.

† Ibid, p. 41.

side of the Mersey, and had drawn the attention of the Rev. D Buckland to them, at the time that eminent Geologist was engag in investigating the glacial phenomena of these islands. M Cunningham kindly accompanied me to the spot a few weeks sinc

The part of Bidston Hill where these striæ occur is formed Lower Keuper Sandstone; the surface of the rock is worn down an even slope, corresponding with the dip of the beds, towards t east, and is covered in most parts by a thin coating of tu Wherever the rock has been newly bared, it presents the phenome of glacial striations; the markings point in the same direction those of Liverpool, which is northward, and are doubtless attr butable to the same agencies. Mr. Cunningham assures me th wherever the drift is newly removed from the rock surfaces alon both sides of the Mersey, as far up as Runcorn Gap, simil groovings are visible; but whether these have been caused b floating icebergs, or by a sheet of ice, as Professor Agass suggested a quarter of a century ago, extending southwards fro the lake mountains, is a point upon which there is still gre difficulty in arriving at a decision.

The thanks of the Society were unanimously voted to Mr. Hu for his communication.

Mr. Binney—I think that Mr. Morton has taken great pains an trouble to describe these appearances. Probably, if Mr. Cunnin ham saw them first, he would see them at the same time as t men who uncovered them. But this does not in any wa take from Mr. Morton the credit of his great accuracy in descriptio and first publication. I have seen these marks myself, and the are the most beautifully scratched surfaces I have ever seen. I the suggested that they would be very likely to exist on both sides

the river, and Mr. Morton went over to the Cheshire side, and, in his published memoirs. previously quoted, said he saw them there as well. As Mr. Morton—a most meritorious and indefatigable Geologist—has been at the trouble of describing them, and putting them before the public, we look upon him as the real discoverer of them, although perhaps Mr. Cunningham may have seen them like many other persons.

Mr. Hull—I have not the least doubt of Mr. Cunningham's statement, because he told me about the matter himself, and, in my presence, appealed to several persons, as to whether he had not called their attention to it years ago. It is quite true, as I have stated in my communication, that Mr. Morton was the first to publish a description of these specimens, and, as such, he is entitled to the merit of the discovery. It it a great pity, when persons do notice any physical phenomena, that they do not publish their observations at once, so that the world might get the benefit of it. A sense of justice, however, obliges me to state what I have stated in my paper.

Mr. Binney—It struck me on looking at the scorings and polishings of this rock, especially on the Walton side, that the force which had done them had proceeded from the land, as if it had come out of the valley of the Mersey. I have remarked the same appearances near Llandudno, in Wales.

Mr. Hull—If there was any ice going up Runcorn Gap, and resting in these hills, we should have some evidence of glacial action. But I have just been over the Kinder Scout district, and can state positively that there is no evidence whatever of any glaciers having existed there.

Mr. Binney—Gentlemen may look for themselves at Walton

and Kirkdale, and they will see the appearances as if they sloped down on the land side. If you take the whole paring down of the rock, it seems as if it had been done by some force coming out of the valley of the Mersey.

Mr. Hull—It does not appear to me that there is evidence to support this view.

Mr. Jos. Dickinson—The description of these striations is all very good, but I think you are jumping to a conclusion in attributing them to icebergs. We have no evidence whatever that they have been so occasioned. It is not unusual in the roof of coal seams, to see these groovings, which are occasioned by some rocks sliding over others. I think it is more likely these grooves may have been formed in the same way, or like as the backs and cleavages of strata have been formed. I think icebergs have nothing to do with them.

Mr. Hull—How do you account for the scored stones?

Mr. Dickinson—That is another question. I might mention that I purpose giving a paper on this subject, and I would, therefore, rather not enter further into it just now.

Mr. Hull—I hope the members will not be led away by Mr. Dickinson's certainly plausible assertions about the glacial theory, because, there is nothing more certain than that the grooving of rock-surfaces is the result of ice; we can trace similar groovings up in the lake districts, where we have got all the phenomena that we observe in the Alps, as the result of glaciers. Therefore, I say, we are not assuming anything, but are arguing from known facts, and inductive reasoning.

Mr. Dickinson—I know Geologists have laid this down as their theory; but, in my opinion, conclusions have been arrived at without any sufficient data; no data in fact but supposition.

Mr. Binney—I think Mr. Dickinson is going rather far back in Geology, and not looking at it as it is considered in the present day. There are some things laid down distinctly and authoratively, and one of them is, that ice has acted very extensively in the drift deposits. I do not mean to say that the striations we see have all been made by glaciers, although some of the specimens of scratched boulders have the appearance of having been moved down from the lake district. Other striated surfaces may have been scratched by ground ice going over them; and others by pack ice in a bay, as in Labrador. Mr. Prestwich, an eminent Geologist, thought that ice had been an agent in forming the high level terraces. I think we ought to be very careful not to attribute everything to ice; but, on the other hand, I cannot make out how these scored rocks and scratched stones have been done by anything else. The stones are also stuck so pell-mell into the clay, that you could not imagine that they had been deposited by any ordinary current of water.

Mr. Dickinson—It would be just as reasonable to attribute all the beautiful laminæ of the coal strata to ice as these.

Mr. Binney—Some gentlemen attribute them to magnetic origin.

Mr. Dickinson—We find our coal cleavage varying here as much as 80 degrees.

Mr. Binney—I believe there are some very good striæ in the Trencherbone, where there has, no doubt, been lateral motion. But if Mr. Dickinson went to Liverpool, and saw for himself, I think he would be very much of the opinion of Mr. Morton.

Mr. Dickinson—I have seen marks said to be formed by icebergs over and over again, which I have thought were just as likely to be formed in some other way.

ON THE DISCOVERY OF COAL IN BRAZIL.

COMMUNICATED BY

MR. JOHN PLANT.

As this Society is a good deal interested in coal, I shall perhaps be permitted to bring before the notice of the meeting a discovery of a coal-field in one of the provinces of Brazil; the facts have been communicated to me by my brother, Mr. Nathaniel Plant, who has been for the last twelve years, more or less, engaged in exploring the almost unknown inland parts of the province of Rio Grande do Sul, in Brazil. The coal-field to which I have to refer, possesses extraordinary features, so much so, that the Brazilians have said it is "*without parallel in the world.*" It has been generally remarked, in most of the works describing the natural productions of South America, that there is a singular absence of coal deposits in that vast continent, especially so with regard to Brazil; and I believe, up to 1859, there was no certain information in print about any deposit of coal existing there; but, as I remarked, my brother has been exploring the country since 1852, and has therefore had occasion to go over extensive districts in the southern provinces of Rio Grande do Sul, examining the mountainous parts for metalliferous deposits; and in 1861, he heard a rumour from some of the residents at San Pedro, that coal had once been found in the extreme south of the province. He made preparations to explore this district, and it then turned out, that a Mr. W. Bouliech, had observed coal there on the surface, the report of which appears to have reached England, for it was quoted by a writer in the *Quarterly Review*, 1860, and referred to by Mr. Hull,

in his work, "The Coal-Fields of Great Britain," 1861. It was there mentioned as being a "vast coal-field sixty square leagues in extent, lying about forty miles from the coast of the Atlantic, and in the province of Rio Grande do Sul." It appears to have been lost sight of until about the end of 1861, when my brother determined to proceed in search of it, and make a thorough examination into its features, and report thereon to the Government. His first report, addressed to the Governor of the Province of Rio Grande, The Illm: Sr: T. Bouliech, is dated April, 1862. The second report is addressed to the Imperial Councillor of State at Rio Janeiro, dated May, 1863; and the third report to the Provincial Governor, dated November, 1863. These reports contain a considerable amount of interesting matter relating to his discoveries of metalliferous deposits of iron, the geological features of Rio Grande, and very full particulars of the coal-field I have now to describe. The locality of this coal-field is at the extreme southern part of the province of Rio Grande do Sul, just on the border lands between Brazil and the Banda Oriental, or Republic of Uraguay, as indicated on the map before the meeting; its distance from the coast in a direct line, may be about sixty miles, but it would hardly be possible to find a practicable route, to bring the coal down this way, as an extensive but shallow coast lake, named Lake Merim, lies between; and the sea-board is made up of a vast extent of dangerous sands and low banks scarcely perceptible a mile from the shore. The river Jaguarao, and its tributaries the Candiota, Tigre, and Jaguarao-chico, drain the surface of the coal-field. The chief stream flows east into the Lake Merim, and that lake finds an outlet on the north by the river San Gonzalo, into a second great coast lake, Lagos dos Patos, which empties itself through the harbour of Rio Grande do San Pedro, this being the only safe opening to the Atlantic Ocean for many degrees along this coast, north or south. The eastern borders of these lakes and rivers, are only separated from the ocean by a narrow spit of sand-banks. The nearest point to which the coal

approaches a port of embarkation is about 20 miles above the mouth of the Jaguarao, and sailing vessels, up to 100 tons burden, carry on an active trade in hides, tallow, and cattle produce, between the town of Jaguarao, (a place of about 10,000 inhabitants, lying 16 miles up the river Jaguarao;) and the port of Rio Grande, so that water carriage exists from the Atlantic port almost up to the coal-field. The area of the coal-field is conjectured to be about 150 square miles, and the coal-basin appears to rest upon mica schist of a much older formation: it is bounded apparently on all sides by syenitic, trappean, and other igneous rocks; in fact, the country lying to the north of the coal-basin, as far as the borders of Lagos dos Patos, is described as being almost a perfectly level tract of basalt in its whole distance of 40 miles; and the idea is regarded with much favour, that a tramway over this route would be more direct and practicable, than for the coal to be brought down to the coast by the circuitous bendings of the lakes and rivers; an engineer is at present surveying the district, for the purpose of estimating the cost of a single line tramway, an item of expense which must be comparatively small in going over a country which is described as being as level as a billiard table.

The principal features of this coal-field, as far as it has been examined, consist in the great depth of some of the coal-beds, and the facilities which it presents in a long escarpment for getting the coal by open quarrying; it would require neither deep shafts, pumping, nor drawing engines, and scarcely a tithe of the expensive "plant" required to work the coal from most other fields;—here the outcrop presents no less than 65 feet of bright bituminous coal exposed along the margin of a river valley, and all the implements required to get the coal will be the miners' pick and blasting powder,—the coal would almost fall unaided into the waggons below.

The section accompanying the map, shows the series of coal-beds from the surface, of 65 feet of coal in 114 of strata: it is an outcrop, and runs along the margin of the valley for about 8 leagues, and can be examined in its entire extent. In some places the interstratified beds have disappeared, and it there forms a solid seam of coal of about 65 feet in thickness; the dip of the beds is about 5°, and generally to the east, or towards the coast. The thickest coal, that to my knowledge has yet been found, is at Pictou, in British America, where there is a small coal-field that has two beds, one of 37 feet, and the other 22 feet; but they are separated by 157 feet of strata. In Bear Mountain, in the States of America, there is coal 40 feet thick, but this is believed to be from the joining of several beds of anthracite coal. In Virginia, near Richmond, there is coal said to be 30 feet to 40 feet thick. Two of these coal-basins afford proofs of being coals of Oolitic age, and not of the true carboniferous. My brother-states, that in Brazil he has found the *Glossopteris*, a fern by which the Oolitic coals are said to be distinguished in Australia, Bohemia, and N. America. This shows that the age of these coals may be cotemporary in different parts of the world. The thickest bed in this Brazilian coal-field, is the lowest of the section, and appears to be 25 feet clear; and then below follows a series of older strata, which have all been traced along the line of the valley, but their full depths have not yet been stated; there is nothing apparently in the underlying deposits which will lead us to doubt the suggestion that these may be Oolitic coals; but I think that is a question which may be left for the present, at least, until the specimens of fossils and coals which have been promised to be sent, have been examined and compared with those already decided upon by Geologists to belong to the Oolitic period.

The following is the section spoken of:—

Section of the Strata shown along the valley of the Candiota, Rio Grande do Sul.

		ft.
	Surface.	
	Light Red Iron-bearing Sandstone	28
COAL.	A Good but Shaly Coal	9
	Sandy Shale	5
COAL.	Hard Coal	3
	Shale and Blue Clay, with Fossil Ferns	5
COAL.	Shining Splintery Coal	11
	Parting of Blue Clay	2
COAL.	Good Deep Coal	17
	Fossiliferous Shale	9
COAL	The Deep Coal	25
	65 feet of Coal in a depth of 114	
	Fossiliferous Shales	Thickness not given.
	Sandstone	
	Limestone	
	Mica Schist	
	Metalliferous Limestone	
	Syenite	

This section may be regarded as correct, as far as it gives the true thickness of the exposed escarpment; that is, down to the base of the bed of coal, 25 feet thick; and these five photographs which I have the pleasure of exhibiting, will convey a clearer notion of the aspect of the face of the high cliffs of coal along the margin of the valley of the river Candiota, than any description could pretend to; they were photographed in November last.

The second coal-field lies away some hundred leagues to the north, in the valley of a river, Dos Ratos, near Porto Alegre, the capital of the province; this basin is small, and much disturbed by igneous rocks; a license to work this coal-mine was granted a few years back, but nothing appears to have been done up to 1863; and, although well situated for easy carriage by river and lake, through the really industrious part of the province, the want of enterprise and capital have prevented it being turned to good account by the people of Rio Grande do Sul.

A third coal-field has been discovered in the small province of San Catharina, lying N. E. of Rio Grande do Sul; it is reported to be a deposit of about 80 square miles, and lying far from the coast, in a range of hills; it appears not to be so readily got at, or the coal to be as good and abundant as it is in the greater deposit at Candiota.

The three coal-fields are ranged as though belonging to one line of deposit, afterwards separated by igneous bosses and tracts of porphyry and basalt, but the fields are not much distorted by faults. They are the first instances of coal having been found and examined in the great Empire of Brazil, with its three millions of square miles of country. It is a most valuable thing to the Brazilian government, who annually import for gas and steam purposes, 250,000 tons of coal, at 49*s.* per ton. The Brazilians, if they are wise enough to open these fields of coal, will be enabled

to supply themselves with coal at 18*s*. per ton, and also to for profitable depôt for the supply of the great ocean steame India, China, and Australia. The supply of coal must be abundant, covering as it does, an area of 150 square miles.

It would, therefore, be an important thing for the Braz government, who pay so heavily for coal, if, by aid of a company, could procure coal in their own empire, and at a price which w pay a good dividend to all parties. Brazilian enterprise is parently not well calculated to carry out successfully any mi operations, either for coals or metals. It requires both Eng capital and skill to carry out these works; and, although my bro has the Imperial concession of the Candiota coal-field, he feel will be almost impossible, unless he finds English capital energy, to make it a blessing either to Brazil or to the comm of the world at large.

In conclusion allow me to say that in a short time I shall h the pleasure of submitting to the members of this Society, specimens of coal and fossils now on their way to England, an may perhaps be able to read a paper upon the geological feat which have now only been communicated as a rough sketch.

The thanks of the Society were unanimously voted to Mr. Pl

The President—Have you been informed whether this is ste gas, or house coal?

Mr. Plant—Taking the coal generally, it is described to be good as any drawn from the British coal mines. It has been t for steam purposes with admirable success; but there is none o anthracitic; it seems to be a bituminous coal, and is well adap

for steam purposes and smelting. It has been tried for gas in Rio Janeiro, and the engineer of the gas-works reports that the coal was very good, but does not give any per centage, by which a proper judgment could be formed of the gas produced.

Mr. James Heywood—Some English house in Rio, has a monopoly of the gas, and they would have a great interest in getting cheap coal.

Mr. Hull—I have always felt that that magnificent country of Brazil, must have coal and other mineral treasures. What the authority was upon which the writer in the *Quarterly Review* grounded his assertion, I do not know; but he stated there was coal. Still, as Mr. Plant has remarked, nothing definite has been known in this country, up to the present time, about the existence of coal in Brazil. I should certainly think that Mr. Plant's brother would have no difficulty in getting capitalists to undertake such a splendid enterprise as that; and, if he would only write a short account of it to "*The Times*," and publish, besides his communication to us, one to the Geological Society, in London, it would awaken great interest in his discovery.

Mr. Plant said the members might rely upon the accuracy of his communication, as he had taken it from his brother's official reports.

Mr. Dickinson— I should like to make one observation as to the position this coal holds, with reference to the strata below it. It is not an uncommon circumstance in many parts of the Scotch coal-fields, to have the coal measures basseting against these rocks. As regards the thickness of the coal, I might mention that our thick coal of South Staffordshire, varies from 8 to 10 yards in thickness; and I have been in seams of coal, at St.

Etienne, in France, from 70 feet to 100 feet of good quality
but the deposit is very varying in its thickness, and it also
upon old rocks, as in the section before us.

Mr. Hull—On the boundary of Russia, Hungary, and Aus
exactly on the point where these two empires meet, there
seam of coal which is not very far from 60 to 70 feet thick.

Mr. Dickinson—In continuation, as it were, of the South W
field, right across the North of France, through Belgium
Aix la Chapelle, at Dresden, and near Warsaw, and all along
line of country, there are dots of this thick coal upwards of 30
thick. From France to Aix la Chapelle, however, it is not so th

Mr. Hull—These Belgian coal-seams are vertical, and even
zag, and may have doubled on themselves.

Mr. Dickinson—On the sections they are generally shown an
lar; but if you go into the mines themselves, you will find that
turns are by curves, or, sometimes, by slips.

Mr. Plant—An interesting point which struck me, was,
extension of these Oolitic coal-fields in one hemisphere. T
probability is, that it is only the commencement of many discover
of this kind in Brazil. The fears that have so recently be
expressed, that we shall exhaust our British coal-fields, will be ve
much diminished if we discover a few more coal-fields like the
in South America.

Mr. Dickinson—I think it would be a safer plan not to attribu
these coal-fields to Oolitic periods merely because of the foss
found there. We have had many proofs that fossils which we
supposed to be distinctive of certain strata, have been found
point quite to another direction. We have found reason to dou

that fossils are the safe guides some persons think they are. It is not uncommon to find the true coal measures of this country resting upon lower rocks, and which I do not believe to be igneous rocks.

Mr. Plant—I have a strong impression, that these Brazilian coal-fields are not Oolitic. It may be a mistake about this species of fern, and it will be necessary to get specimens in England, in order to form a correct opinion; although my brother speaks most decidedly of finding the ferns which are characteristic of the Oolitic deposits of Australia.

Mr. Hull said many proofs had been given that these deposits were distinctly Carboniferous, and not Oolitic.

Mr. Smith—Have any shells been found?

Mr. Plant—Yes: several in the limestone and shale.

Mr. Atkinson—It is reasonable to suppose that during the deposition of the coal strata, there would be a diversity in the vegetable forms of tracts so widely separated as Brazil and northern Europe. *Glossopteris* might exist in the sub-tropical regions of Brazil contemporaneously with the plants forming our coal-beds, though that plant itself did not grow here. Climates would, no doubt, differ in different latitudes in the carboniferous period as now; and it would therefore hardly be safe to decide beforehand that none but absolutely similar fossil plants must necessarily characterize contemporaneous deposits of coal all the world over.

Mr. Smith said he also was of opinion that the formations which were now going on, showed that fossils were not altogether to be relied upon for proving strata to be contemporaneous.

The President—Are we to understand that this coal in Brazil, is to be seen all over the coal-field, with little, if any, covering on it?

Mr. Plant said the photographic views which had been sent, were from an escarpment which extended over three leagues, in a valley.

The President—If there are prairie-fires in the district, it strikes me that if much of the coal is exposed, it will be in danger of getting on fire and being burnt up.

Mr. Plant said there was no danger of that, the surface of the district is generally overspread with deep clay and drift.

A vote of thanks having been given to the President, the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 13.] VOL. IV. [Session 1863-64.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, February 23rd, 1864.

ANDREW KNOWLES, ESQ., the President, in the Chair.

The President announced that Mr. E. Hull had presented to the Society, one of the "Memoirs of the Geological Survey," "On the Geology of the country round Oldham, including Manchester and its suburbs."

The thanks of the Society were given to Mr. Hull for his donation.

Mr. Dickinson exhibited a number of specimens taken from the rocks now being tunnelled through the Savoy side of Mont Cenis. He said, I have here a selection which I myself made when examining the works a few months ago. They appear generally

to be from metamorphic rocks, and as yet, I believe, no granite has been touched upon. The commonest of the specimens is a piece of chlorite schist, and that I took from the far end of the tunnel, which had then been driven a distance of about 1100 metres. In the neighbourhood there are some masses of limestone; but the most interesting mineral of all is the coal, which is found associated with these metamorphic rocks. It has, I was informed, been cut through in different places in the tunnel, but I myself only saw one, the others being walled up. Between San Michel and Modane, similar coal is being worked to supply the district.

Mr. Atkinson—What is its thickness?

Mr. Dickinson—It is as irregular as the rocks themselves are. In one part no coal whatever is to be found, but it gradually wedges in and extends downwards, and then tapers out again. The thickest I saw was at San Michel, and that was about six feet thick. It is anthracite coal, very similar to the Welsh anthracite. There is no regular dip at all in any of these rocks. In one part you may see them standing up like a cone. As for the coal it is impossible to say which is the roof and which is the floor, as it is sometimes vertical, and it dips in such a variety of directions. I examined both the roof and floor of some of these seams very carefully, and could not find any trace of the *stigmaria ficoides*. Of course I do not say there are none, but I could not find any. I brought away a piece of the rock which adjoins the coal, and I find that it partakes of the nature of shale.

Mr. Atkinson—Are there no stratified rocks near?

Mr. Dickinson—No, not more than the bedding sometimes met

with in metamorphic rocks. Neither is the limestone stratified; but it lies in large masses, the same as the quartz. The masses are partially laminated, and the coal lies imperfectly bedded. The tunnel will be 12,220 metres long, and it will be the greatest work of the time, when completed. I ought perhaps to mention that here and there the quartz and limestone, instead of taking the shape of solid rock, is like snow or flour, and is used in making the mortar which is used in the tunnel.

The thanks of the Society were unanimously voted to Mr. Dickinson for his communication.

Mr. Eskrigge, of Liverpool, suggested that the Manchester Geological Society should join with the Liverpool Society in an excursion to Llangollen during the coming season. He was returning to Liverpool, and the Society there, he knew, would be very pleased to receive a favourable report of the suggestion.

Mr. Atkinson said he thought it would be an excellent plan if the two Societies joined in an excursion to Llangollen. Last summer the members had a very pleasant day at Matlock Bath, with the Dudley Society, and on that occasion it was discussed whether we could not get up an excursion this year to Llangollen. It would be well if the Liverpool, Dudley, and Manchester Societies could join in the trip. The mountain limestone formation in the vale of Llangollen, would be an excellent thing to examine.

Mr. Eskrigge said there was no better place for seeing the mountain limestone, and Mr. Davis, of Oswestry, who was an

excellent authority, would no doubt be very glad to accompany the excursionists. Mr. Davis had found, in the millstone grit, fossils which had never before been found there.

In the course of a conversation which followed, the suggested excursion met with general approval; but upon the recommendation of Mr. Atkinson, it was resolved not to decide upon the subject until the details as to the time, &c. of the excursion were agreed upon by the Liverpool Society.

Mr. Hull—Before the reading of Mr. Taylor's paper, perhaps I may be permitted to remark that he (Mr. Taylor) has recently published a volume of Geological Essays which I think very highly of, and as they relate to the geology of our own neighbourhood it is right, I think, that some notice should be taken of them before the Society. Mr. Taylor is a very sound geologist, and these essays are written in a very popular strain, so that any general reader may be interested in the subject. He introduces a good deal of general literature—as far as geology is capable of illustrating it—and gives some highly interesting sketches of excursions in different parts of the country. I think it will be a very useful hand-book for the geologists of the neighbourhood, and it is certainly very creditable to the author.

Mr. Atkinson then read the following—

ON THE

DRIFT DEPOSITS IN THE NEIGHBOURHOOD OF CREWE, CHESHIRE;

By John Taylor, Esq.

The great Cheshire plain is overlain by a series of deposits, rather more regularly stratified than is usually found in hilly

grounds. Here and there, where the country undulates gently, the upper beds may be studied along the channels of streams, &c.; but the general flatness of the country prohibits an acquaintance with the underlying beds. These have to be studied from well-borings, and the principal object of this paper is to lay a few facts before the Society, collected from a series of well-borings, which were carried on during my residence in the neighbourhood of Crewe.

In a southerly direction the drift deposits of the Cheshire plain are abruptly terminated by the high grounds at Whitmore. Here the red sandstones of the Permian crop out, and are only overlain in other places by a few beds of red sand, derived from the abrasion of the underlying rocks. Whitmore is about one hundred and ninety feet higher than Crewe. The line of the London and North Western Railway, between the two stations, frequently passes through gullets, where the alternating beds of sand and clay are seen on either hand; in other places it is carried through valleys by a high embankment. The undulations of the country therefore, between the two places, is caused by denudation in the upper or drift deposits.

At Barthomley, about four miles from Crewe, there are several gravel pits opened on the grounds of Lord Crewe. In several of these, mixed up with pebbles of granite, greenstone, trap, porphyry, and sandstones, were numerous fragments of *flint*. Several of these, which bore marks of having been cut and chipped, I had the honour to lay before the notice of the Society about a year ago. Their abundant occurrence, associated with the fragments above mentioned, is somewhat singular as compared with the usual pebbles of our Lancashire gravels, and their numbers cannot fail to strike the geologist. At a rough guess I should think they were mixed up with the rest in the proportion of one in three. These

gravels rest upon a thick layer of sand, which, at Crewe is ag overlaid by a stiff layer of clay, to the exclusion of the cos gravels. The sand bed at Barthomley contains numerous fi ments of shells, together with entire valves, chiefly of *Astarte.* brought away several whole specimens of the above genus.

About half a mile on the north side of Crewe the clay was bo through for the purpose of well-sinking, and here it occurred a regular laminated form.* What struck me as being somew singular, was the occurrence of vegetable matter on the surface these clay layers. The clay was dug from a depth of about thi feet. The vegetable matter had the colour of straw, and v pyritized; but the mineral composition changed after it had be subjected to the action of the atmosphere for some time.

On the west side of Crewe several well-borings have been ma In various places where the sand comes up there have been d quarries for the purposes of excavating it. The water supply rather variable; what is easily obtained in one place being wi difficulty found in another. This, I believe, arises from t undulating state of the ground here about, and the numero brooks and streams which drain off the water from the upper be The various layers of different material add to the complexity well-boring, and it becomes a matter of chance to find water, rath than finding it with a foreknown certainty.

During the boring of one of the deepest of these wells, I atter ed constantly in order to obtain all the information I cou respecting the beds through which it passed. The well is by f the deepest in the neighbourhood, and the following are the be and their several thicknesses through which the sinkers passed.

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*This lamination of the till was exhibited in the cuttings on the Stockport a Woodley Railway in a more regular and stratified form than even these bed Crewe. In the former place the layers rest upon each other as regularly as beds of shale or limestone.

Sand	21 feet.
Fine Shelly Gravel	3 ,,
Ochreous Sand	3 ,,
Shelly Gravel and Pebbles	3 ,,
Fine Clay	8 ,,
Stiff Pebbly Clay, with Shells*	30 ,,
Loamy Clay	8 ,,
Total	76 feet.

I was surprised at the great number of shells met with in the layer of "fine shelly gravel." One could scarcely take a handful without seeing a number of fragments. Entire specimens were not rare, and of the fragments and whole shells I identified the following: *Bucoinum undatum*, *Turritella terebra*, *Venus*, *Astarte*, *Tellina* and *Mactra*. This bed was separated by "ochreous sand" from another layer beneath, which contained similar shells.

The "fine clay" was generally devoid of them, but the "stiff pebbly clay" underneath contained them in great numbers; almost every lump taken in the hand was dotted with thin white fragments, and here and there could be dug out whole valves. With the exception of *Turritella* and *Buccinum*, there were the remains of the shells above enumerated.

I have called the underlying bed "loamy clay," because it was an admixture of fine sand and clay. At this depth water began to ooze in at the bottom of the well. There were intercalated in this loamy clay, not layers, but what might be appropriately termed "pockets of sand"—that is, separate and irregular deposits.

* I notice in the discussion which followed the reading of this paper, that some doubt existed regarding the *glacial* character of this clay. I may state that, though no large boulders are found in it, those which are met with have unmistakable evidence of glacial action. They are both polished and striated.

J. T.

In going towards Manchester from Crewe the overlying c thin out, and at Sandbach the underlying sands form the secti on either hand of the railway. The sand is here intercalated numerous thin seams of coal-dust, which have been denuded carried away from the outcrop of the coal-seams of the Ches coal-field. In composition the sands seem to be similar to th at Stockport Station.

To the west of Crewe, in the upper beds, have been fou mammalian remains. Whilst I was at Crewe, I had sent me b gentleman at Northwich, an Elephant's tooth, which he h himself discovered in these upper beds. The tooth seemed to that of the *Elephas primigenius*. Doubtless other mammal remains would reward careful observers; and it would be w if the gentlemen in charge of the salt mines would carefully p serve any fragments of shells and bones met with in bori through the superficial deposits.

I submit these notes to the Society without drawing any c clusions; conscious that the interests of geological science are b served by recording carefully arranged and observed facts.

The thanks of the Society were unanimously voted to M Taylor, for his interesting communication.

Mr. Plant—It appears to me that this paper shows the compo tion of the drift beds at Crewe to be very different from thc about Manchester. Mr. Taylor does not give us an idea as to t particular position to which he would ascribe this drift. In th neighbourhood we have none of the shells which he finds in su great abundance at Crewe. This shows a striking dissimilarity the drift, although the deposits at Manchester and Crewe mu

have belonged to the same great volume of water which deposited the drift from Liverpool right away to Shrewsbury, yet I very much doubt myself whether the till mentioned by Mr. Taylor is the till found in this neighbourhood, because their palæntological characteristics are so different. The till about here is rather distinguished by the prevalence of glacial boulders than any fossil remains; and Mr. Taylor's paper shows quite a shelly deposit.

Mr. Hull—It does not appear to me that there is any material discrepancy or great difference in the series of beds at Crewe, as compared with those at Manchester. I differ from Mr. Plant in that opinion. Mr. Plant will find on the coast of the Irish Channel—take Blackpool for instance—plenty of fragments of shells in stiff boulder clay ; but because they are not found in this neighbourhood it is no reason why they should not be the same beds as Mr. Taylor has here described. From what I know personally of that neighbourhood, I feel quite satisfied that the Crewe series of fine sands and ochreous gravels are what Mr. Binney called forest sand, existing at Cheetham and Crumpsall, and the stiff pebbly clay is the same formation as the lower till of Manchester. It is almost invariably found that there are very few shells where the beds come near the surface, as the calcareous matters are perhaps dissolved. But below the sand, and in depths such as are found by well-boring, and where, in fact, they have been preserved from atmospheric agencies, they are plentiful enough. I do think that the section sent by Mr. Taylor corresponds in the main with the arrangement found in this locality, where, however, we have a superior formation of till or boulder clay above, which is not mentioned in the section before us, but which occurs at Crewe Station. There are two periods of boulder clay and sand between.

Mr. Plant—Although I must bow to Mr. Hull, I should like to

point out that he has not accounted for the great diversity between the till described by Mr. Taylor, and that found here. There we find a great shalyness in the clay, abundance of shells, with an absence of the glacial boulders which distinguish the till of Manchester. How is it they are absent in the Crewe deposit?

Mr. Hull—Mr. Taylor does not say they are not there. He mentioned a bed of "shelly gravels with pebbles," and one of "stiff pebbly clay with shells."

Mr. Atkinson—Nor does he say the clay is shaly; it is sometimes laminated.

Mr. Hull—Large boulders are certainly few and far between in the district about Crewe.

Mr. Plant—I think you will find when you compare the drift of Manchester and that of Thelwall, as described by Mr. Atkinson, with the deposit about Crewe, the two first are easily harmonized. I had from Mr. Taylor himself a description of the drift from Crewe, and the peculiarity he alluded to was an almost entire absence of those glacial characters so abundant in Manchester; and a great abundance of recent shells which are entirely absent here.

Mr. Hull—Allow me to remind you that these shells have been found at Bowdon, in the sand there, and that is not so very far from Manchester. I have seen the till also in Crewe, and it is not so much different from that in Manchester. In Manchester, in some places, the till is quite shaly, or rather, laminated. We find boulders very much further south than Crewe; they occur in immense numbers not far from Wolverhampton.

Mr. Plant—Mr. Taylor also alludes to the discovery of flints; and Mr. Binney has admitted that he has never found a flint in this neighbourhood. I myself offered a reward for flints to some men working in wells, and one has never been found; and the only approach to it has been some pieces of black chert. When the men were excavating the dock for the great manure deposits on the north side of the Irwell, near Ordsall Lane, they riddled a thousand tons of gravel, and not a single flint was found. But in Crewe the flints are abundant.

Mr. Atkinson said he had found one or two flints in gravel from High Leigh.

Mr. Plant—I have seen these gravels at High Leigh, but I did not find a single flint, but several specimens of chert, which I think comes from the mountain limestone. No true flint has been found near Manchester.

Mr. Aitken said that at Bacup, eighteen or twenty miles north of Manchester, he had picked up two flints 800 feet above the level of the sea.

The President—What is the total thickness of each deposit in the two localities—Manchester and Crewe?

Mr. Hull—It varies a good deal. There will be boulder clay fifteen or twenty feet in thickness; then there will be thirty feet of sand; and there might be forty or fifty feet of lower till, and then you may come to the red marl. But there is no saying what the thickness of the drift may be, because it varies so much. Still it is a wonderfully regular deposit, considering the manner in which it

was formed. I had a flint the other day found at Stockport in the gravel. It was a true flint, and was coloured outside. At the same time I acknowledge there are very few flints in this locality.

A vote of thanks to the President concluded the proceedings.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 14.] VOL. IV. [Session 1863-64.

The Monthly Meeting was held in the Museum, Peter Street, on Easter Tuesday, March 29th, 1864.

ANDREW KNOWLES, Esq., the President, in the Chair.

Mr. E. W. Binney exhibited some interesting fossil crustaceans, found by Mr. Birtwell, of Gawthorpe, in small ironstone nodules, in the middle coal-field. He (Mr. Binney) said that two of them appeared to belong to species of the genus *Limulus*, and the remainder to the genus *Pygocephalus*. He wished the members of the Society would direct their attention to the interior of the ironstone nodules of the coal-field, and bring before the Society any specimens which they might meet with. He also stated that he had himself found reptilian remains in the Lancashire coal-measures, in the middle series, both at Oldham and Heywood. They belonged to a *Labyrinthodon*, probably of Mr. Huxley's genus of *Anthracosaurus*. He hoped that by diligent search the members might bring before the Society some further specimens of these interesting remains.

The following Paper was then read:—

ON THE

LIAS OF CHESHIRE AND SHROPSHIRE;

BY R. A. ESKRIGGE, ESQ.

The existence of a considerable deposit of Liassic age, lying partly within the county of Cheshire, and not more than 36 miles from Manchester, so that it can easily be explored in a summer's day excursion, allowing 8 to 10 hours for field work, may perhaps be new to some members of this Society. That such is the fact, however, has been well determined, and the supposed boundaries of the patch have been laid down in the ordnance maps, since the district was surveyed by Sir R. Murchison, in 1834.

It was previously supposed that nearly the whole of Cheshire and the north of Shropshire were occupied by one or other member of the trias, the saliferous beds of the red marl, the highest of that formation being there developed very extensively, whilst all round it to the S., W. and E. the Bunter sandstone is thrown up by a series of faults. Being curious to examine a deposit so far isolated from others supposed to be of the same age, and withal so near home, I recently paid two visits of a day each to the locality, in company with Mr. Morton, Secretary of the L.G.S., a most indefatigable student in the field; and though I fear I shall not be able to present anything absolutely new, yet as these visits were productive to myself both of pleasure and instruction, and as there are some points of special interest in connection with this outlier of a great formation, I hope I may be excused occupying a portion of your time by a description of it.

The general outline of the deposit (as shown on the map) is an irregular ellipse, with a major axis of some 12, and a minor of 4 to 5 miles, in a direction N.E. to S.W. from Audlem and Burley Dam on the north, to the foot of the Hawkstone Hills, and near the town of Wem, on the south. Its boundaries are nowhere

clearly determinable, owing to the vast depth of driftsand, gravel and boulder clay, which covers the country, and prevent a proper examination of the underlying strata, so that its extent is in some directions more a matter of inference than of actual observation.

The surface of the country is for the most part a gently undulating plain, and only rises to a hill at the village of Prees, not far from the southern border of the deposit; to which hill, or rather to the nature of the rock of which it is composed, I am inclined to believe we owe in great measure the preservation of the deposit.

Alighting from the rail at Whitchurch, on the Crewe and Shrewsbury line, the village of Audlem lies about 6 miles to the east, and, as the ordnance map indicates by dip marks, that the lias is visible in several places in that neighbourhood, we made this our first point to be aimed at. Thinking it well to verify if possible the nature of the adjacent rock, we looked out upon the road for any cuttings which might allow us to examine it, but the country is so covered with drift that it was only after a considerable search along bye roads that we discovered two sections where the red marl is well exposed, presenting its usual well-known features.

Upon reaching Audlem we soon found the spot where according to the map the lias should be seen, but after following for some distance the course of a brook which has cut itself a deep bed through the diluvial deposits, and where if anywhere in the neighbourhood the subjacent rock should crop out, we could find no trace of it, and we were forced to the conclusion that the embankment of the new branch line just opened from Nantwich to Market Drayton (and which by the bye is the most direct way to Audlem) passes over the spot where the lias was formerly

visible. This was sufficiently disappointing, but at a little more than a mile distant, at another point indicated in the map, in the middle of the Butterley Heys Farm, we were more successful. Here again the chance of seeing the rock is due to the accident of a small brook having cut through the superficial deposits. The rock exposed in the banks is of small extent, but along the bed of the runlet the shales of the lower lias are unmistakable. The rock is a blue gritty shale, weathering into small fragments and is very similar in character to the upper beds of the deposit of the same age in Robin Hood's Bay, Yorkshire, where it comes out from under the marlstone. The upper lias shales are generally of a smoother texture and more finely laminated. Almost the first blow of the hammer revealed organic evidence of the age of the deposit (if organic evidence is ever again to be relied upon), not indeed in a beautiful ammonite, such as we had pictured as the reward of our morning's hungry labour, but in a tolerably perfect Lima, soon followed by a Pecten, and a Mytilus, all sufficiently distinctive for recognition. We also saw a few rough nodules of ironstone. The dip of the beds is slight, inclining towards the S.W. Doubtless many more fossils might be found, but our arrangements would not permit of a long stay, as so much time had been consumed in finding the spot, none of the rustics being able to give the slightest information as to where one could see the rock, or what it was like. Retracing our steps towards Whitchurch, we next came on the rock at a brook which runs under the road near Burley Dam ; the shale here is harder, and more slaty in character, and contains, so far as we could see, few fossils, amongst them a small modiola (probably minima) and a pecten. The dip here is almost due south at a small angle. This exposure is not indicated on the ordnance map, but within half-a-mile of it, in a wood bordering Combermere Park, on the same brook last mentioned, there is a dip mark ; but the rock appears to be rather a passage bed from the trias than to belong to the Lias, consisting of a greyish white marly sandstone, compact and sharp sounding

under the hammer, but breaking with a rounded fracture, like the red marl. It contains no traces of organic life.

If one could have followed up this brook from the point where it crosses the Whitchurch and Audlem road to this wood, the junction of the two formations might be found, but the banks are so overgrown with brambles that, especially in autumn, it would be a task of some difficulty; and though it would have been very interesting to have found the exact point where these two worlds met, so different in their conditions and in the character of life they sustained, just as it is always interesting to stand on the boundary line of two great countries, or to mark in history the transition point from one epoch to another, we were forced to recoil before the briarean obstacles in our path.

Having examined as far as practicable the northern border of the Lias, we took train from Whitchurch to Prees, the country between these places being a gently undulating plain, covered, so far as we could judge, with drift. Prees stands on a hill, which is much the highest ground of the whole patch, and though marked lower Lias on the ordnance map, we soon found the rock to be the marlstone, the middle member of the system.

The rock (which is well exposed in a road-cutting leading from the lower village to the church, on the crown of the hill) is a light brown argillaceous sandstone—sometimes calcareous in imperfectly formed nodules, and with some bands of a very hard stone, which appears to contain more or less iron. We soon found traces of a vanished life, the holes from which belemnites had been extracted by the village lads, or had weathered out being numerous—beyond these, however, we found no fossils here.

A more profitable section lies a little to the S.W. of the church, by what is locally called the "Yew Cheer" (from a

venerable yew tree, whose exposed roots form a rude chair); it is a broken bank in a field exposing the rock for some 30 yards in length and 15 or 20 ft. in depth. This afforded a good opportunity of searching the different beds, and we found a considerable variety of fossils, most of them however of small size, but all characteristic of the middle Lias. The upper beds which lie, so far as we could judge, below those on the hill side previously mentioned, are of the same lithological character, whilst the lower ones become gradually darker in colour, passing from a brown marl into a blackish clay and then to beds more shaly, approaching in character those of the lower Lias, and doubtless had the nature of the ground permitted our examination a few feet lower still, we should have come upon regularly laminated shales. The fossils as usual in Lias beds were not scattered promiscuously through the whole, but one level gives Lima, another Avicula, another an Ammonite of one species, and so on. Belemnites, however, seem common to all the beds, and in the dark semi-shaly beds low down exist in great numbers, one small piece of rock, not more than a foot square containing no less than 20 individuals, in fact even in the shales of the Yorkshire coast, I never saw them so numerous.

A search of about four hours, on the two occasions we visited the spot, gave us some 20 species of fossils, a list of which is appended to the paper.

Here the dip is northerly, the exact opposite of the direction at the other extremity of the patch, and as wherever over the whole area the rock is visible, the inclination is at a low angle towards the centre of the deposit, it is pretty evident that the whole beds lie in a trough or elliptical basin-shaped hollow in the red marls; whether the Lias is conformable to the Trias we cannot be quite sure, as the points of junction are so obscure, but as the dips in

several cases, where the two rocks can be seen at a short distance from each other, seem about parallel, the presumption is in favour of their conformability.

One of the chief points of interest, however, in connection with these beds is a practical one, viz., that numerous borings for coal have been made through the Lias; indeed it was through accidentally hearing of these experiments that Sir R. Murchison was first induced to explore the district more carefully, and but for this, geologists might still have believed that the red marl was continuous over the whole area.

The shales of the lower Lias present a superficial resemblance to those of the productive coal-measures, and indeed some of them would burn impurely, so that we cannot be altogether surprised at the error having arisen; and notwithstanding that Sir R. Murchison, in his "Siluria," shews by the clearest sections that the red marl must underlie the whole of these Lias beds, and that probably the vast depth of the Trias and Permian would also have to be passed through before reaching the coal-measures, even supposing them to be persistent beneath this tract, the entire population of the country-side is still fully persuaded that immense treasures of coal lie beneath their feet, and only want getting.

The favourite explanation of the frequent failures is that the miners were bought off by large coal proprietors elsewhere, just when on the eve of success, or, which is a shade more probable, the money failed before they had gone quite deep enough. We were ourselves set down as having come to find the most likely spots for fresh trial pits. And, gentlemen, if the doctrines inculcated by the paper read at our last meeting but one are to prevail, and the evidences of the imbedded organisms are to be treated as worthless for determining the true position, and by analogy of similar deposits elsewhere, the mineral contents of strata,

then it appears to me there is no lack of wisdom in the neighbouring gentry preferring the dictum of some practical coal miner, ignorant of geology, and who goes on mere apparent resemblances, to the deductions of that distinguished ornament of our science, before referred to, viz., Sir R. Murchison.

There could hardly be a better practical illustration of the value of geological science than in the many thousands of pounds here thrown away by a bigoted disregard of its teachings. If any further evidence be required as to the futility of these searchings for coal, it may be found in the fact that in more than one place the shales have actually been bored through and the works stopped by the bursting in of brine springs. We visited one of these borings within half-a-mile of Prees, on Lord Hill's land. It has only been recently abandoned after passing through some 450 feet of shales, on account of the influx of water, probably borne up by the red marl. On the bank we found heaps of shale evidently lower Lias, containing many fossils, amongst them two species of Ammonite. There were also a number of calcareous iron stones, resembling the cement stones of the Yorkshire coast, and though most of the fossils were of small size, I found the phragmacone of one large Belemnite, the upper *septa* of which was almost 1in. in diameter, indicating an individual fully 10in. to 12in. in total length.

But perhaps the most interesting consideration in connection with this deposit is how it got into its present position. It is as though a traveller over a wide tract of dreary desert land, with no trace of present or past civilization, should suddenly come upon the half buried columns of a stately edifice. His first impulse is to explore the ruins, to trace their extent, to find out the general plan of the building, and the relation of the several parts to the whole, and then he will proceed to speculate on the character of the civilization possessed by the builders, and their place in the

world's scale of progressive development. He does this by tracing the relations of the style of architecture to that of similar buildings elsewhere; and from the character and subjects of the sculptured ornaments, he may infer much as to the religion, the philosophy, the modes of life and the history of the builders. Again, by searching out the nearest places where similar monuments occur, much may be learned as to the direction in which civilization has travelled, and a flood of light be thrown on the migration of tribes, their affinities with other races, and the length of time that may have elapsed since their decay, together with the causes that have produced these changes. A similar interest is excited when in wandering over the desolate lifeless tract of the red marls representing a wild sea marsh of past ages, which by alternate elevation and depression was subject to successive irruptions of the ocean, we come suddenly upon the bed of an ancient sea, teeming with the remains of a life that indicates conditions of existence quite different from those previously obtaining. Having examined the lithological character and traced out as far as practicable the boundaries of the beds, and obtained some knowledge of their organic contents, it remains to establish if possible their age, and their connection with similar deposits elsewhere. For this purpose the fossils serve the same end as architectural style and ornament, and we at once conclude from identity of organic remains that these beds belong to the same age as the Lias, the lowest member of the great Oolitic formation.

The Lias, as you know, extends in an irregular diagonal band of no great thickness across England, from Lyme Regis in Dorset in the S.W., through Somerset, Worcester, Warwick, Leicester, Lincoln, and on to the north of Yorkshire, where it is well exposed in the cliffs of Whitby and Robin Hood's Bay. From the north of Somerset again it crosses into Wales, shewing that it was deposited before the present drainage system of the S.W. existed. And besides the Shropshire deposit of which we are

treating, there exist two smaller outliers in Staffordshire, a considerable distance from the main band, and also one n Carlisle, not generally laid down on the geological maps. So as England is concerned these are, I believe, all the Lias b known, and it is important to note that it almost everywhere serves the same relations to the red marl, appearing to have b deposited in regular succession conformably upon it, just as Oolite was on the Lias. But it has been suggested by Sir Murchison, in his great work, that by extending our researche Ireland and Scotland, we may find some light on the otherw anomalous position of the Shropshire Lias beds. What so emin an authority has only ventured to think possible, it would be sumption in me to maintain unreservedly, but after devoting c siderable thought to the question, there are several considerati which make the former connection of this deposit both with main English band and the outliers of the north of Ireland, a the east and west coasts of Scotland extremely probable.

In the first place, there are the intermediate beds in Staffo shire, and that near Carlisle, which furnish important connecti links with the main formation. Also the South Welsh b previously mentioned, proving that great changes in the physi geography have taken place since the deposition of the Lias.

Then, again, Sir C. Lyell has shown us in the interesting a most instructive maps figured in the "Antiquity of Man," that submergence of only 600 feet over the whole area of the Briti Isles would reduce them to a group of islands, the mountainc districts of Wales, the Lakes, and Scotland, with the hilly coun of Yorkshire and Lancashire, forming the largest of the gro whilst most of the southern part of the country would be who submerged. Now, without asserting that 600 feet is the ex measure of subsidence required to lay all the Lias beneath t

ocean, for parts of it would be submerged with much less depression, and others would require more, I would just borrow the principle, and suppose that after the deposition of the coal-measures and the Trias, a great subsidence took place, probably to considerably more than 600 feet, as the subsequent denudation of the red marl is very great, and that all round the shores of the islands thus formed the Lias beds were tranquilly deposited. Then, after the lapse of ages, the same area was re-elevated, and during this emergence, the Lias in the north-west was denuded, except in a few isolated patches. It will be observed by looking at the map that on both sides of the Pennine chain the formations succeed one another in regular ascending order, and that to the east the Lias follows the red marl, whilst it is wanting on the west. The theory I would propose is that it formerly lay on the west also, but has been removed by subsequent denudations. The identity of some of the fossils of Prees with those of Brora, in Sutherlandshire, and of Ireland, tends strongly to confirm this hypothesis.

It is by affording data for the investigation of such problems as this that the outliers of great formations assume their chief importance, for we are forced to consider the series of changes that have led to their isolation, and whether the solution attempted above be the correct one or not, it will, I hope, lead to such discussion as may tend to throw light on the question.

Fossils of the Marlstone.

Ammonites geometricus.
Ditto 2 species.
Gresslya rostrata.
Belemnites—2 species.
Avicula inæquivalvis.
Pecten æquivalvis.
Panopæa.
Lima pectenoides.

Of the Lower Lias Shales.

Pecten—2 species.	Encrinite stem Fragments crustacean } Doubtful
Ammonites—2 species.	Mytilus.
Belemnite—1 species.	Modiola minima.
Lima—2 species.	Nucula ovum.
Pholadomya	Astarte.
Avicula inæquivalvis	5 other small bivalve shells.

The thanks of the Society were unanimously voted to Mr. Eskrigge for his paper.

Mr. E. W. Binney said that he was obliged to Mr. Eskrigge for bringing his paper on the Cheshire and Shropshire beds before the Society. Some years since he had found a large patch of Lias a little to the north-west of Carlisle, at Quarry Gill and Oughterby. Taking this deposit, as well as similar ones near Belfast, he had no doubt but vast denudations of Lias had taken place, and not only of Lias, but Oolite, Green Sand, and Chalk formations, as well in the south and north-western parts of England and the north and west of Scotland. In this county nothing higher in the geological series than the Red Marls of the Keuper had been met with, but it was possible that Lias might be found under the drift deposits of parts of the Lancashire coast, between Southport and Lancaster. On the Blackpool coast, in the drift, he had in the course of twenty years found many Chalk flints, and three or four specimens of Lias limestone, containing the *Gryphæa incurva* and the *Ammonites communis*, which might have been derived from the Cambrian or Irish beds before alluded to, or even nearer deposits in the Irish sea.

Mr. Joseph Dickinson said Mr. Eskrigge, in referring to the occurrence of fossils, had not conveyed what was intended. For himself, he (Mr. Dickinson) said that particular fossil shells were

not to be treated as worthless, but as good general, although not infallible guides, and it was so set forth in his Paper; and also that fossils, both of shells and vegetables, were frequently found stratified, particular kinds of shells being sometimes distinctly stratified from each other. Boring for coal in the Lias should not altogether be smiled at. Coal occurs in strange places, and under the Lias near Bristol he has himself been in good workable coal mines at a shallow depth, and which are overlaid and hid by Lias.

Mr. Eskrigge said that if a ledge of rock extending out into the sea were followed, it would be found that certain zones supported certain forms of animal life peculiar to themselves, varying according to the depth of water; and that probably the same principle would account for particular fossils being found only at particular levels.

Mr. Binney said that he thought Mr. Eskrigge had not referred to old sea bottoms, which once formed the ground above, and were then buried. Nothing was seen in the Lias beds but old sea bottoms. Of course there would be variations in depth, and their inhabitants would therefore vary considerably. What had always struck him was the persistency in organic remains of these Liassic deposits over such immense areas. He could hardly have expected such uniformity. With regard to plants it was quite a different thing. Drifted plants would vary according to the currents which brought them, but an old coal seam, with its roots in the floors, and its stems above—for he did hold that they were stems and not mere chimneys for conveying out gas—was no doubt the result of subsidence in muddy water. If such subsidence were sudden, the water would rush in to fill up the hollow produced, and it would knock down many of the plants growing there, and they would be drifted and buried among the mud. But if it were very gradual, the trees would go down like a ship with

all her masts standing. They would go down erect, and a g
deal of foliage would drop into the mud and be retained, as
are now found in the coal shales.

Mr. Eskrigge said that Mr. Strickland, of Whitby, was
paring a book on the Ammonites of the Lias, and he had found
each of them a zone, although they numbered 150 or more.

Mr. Binney said he had no doubt about one particular Ammo
being up to this time found in only one bed, but he disagr
with the statement that a bed of coal could be identified by
fossil plants. Twenty-five years ago he thought this probs
could be done, but after all those years of experience he m
say that so far from any particular fern, or Lepidodendron
Sigillaria, guiding him, he could not come to any decisive con
sion from their occurrence. Whether he went to the carbonifer
strata just above the old red sandstone in Scotland, or to
highest coal-measures at Ardwick, it was the same—he could
positively identify a seam of coal by the plants within or about
although they afforded him valuable assistance, taken with otl
circumstances.

Mr. Dickinson said this confirmed what he had said, t
fossils were only to be taken as a good general guide, and not
be relied upon in particular instances.

Mr. Binney said that in examining the higher beds of
Trias, and the lower ones of the Lias, he had great difficulty
drawing the absolute line of demarcation between the two for
tions. This was especially the case in Lincolnshire.

Mr. Plant said he quite admitted the difficulty there was
finding out a well defined line of demarcation between the L

and new red marl. But a few weeks ago he was at Barrow-upon-Soar, in Leicestershire, which had always been famous for its liassic fossils; and in one field, where a spot was bared, he was enabled to point to where Lias and new red marls joined together; and it shewed distinctly the outcrop of the lowest band of Lias marls, and also of the new red marls. So distinctly was this visible that it was possible to step upon one and the other at the same time.

Mr. Binney said that along the valley of the Trent they were a lot of yellowish clays, lying upon the red marls, and under the Lias, and these beds were his difficulty.

After some further conversation, the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 15.] VOL. IV. [Session 1863-64.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, April 26th, 1864.

ANDREW KNOWLES, Esq., the President, in the Chair.

Captain Aitken, on behalf of Mr. James Henry Ashworth, of Rawtenstall, exhibited a pair of antlered horns, a bone, and a short horn, and stated that the antlers and bone were discovered whilst excavating for a drain in a bed of river gravel, six feet from the surface, in the valley of the river Irwell, near Rawtenstall. The gravel was very coarse, containing numerous large sandstone boulders, weighing from one to two cwt., and was principally derived from the carboniferous rocks of the surrounding hills, mixed with granite and trap pebbles. The river appeared to have changed its bed frequently, and had doubtless at one time flowed where the discovery was made. The antlers and leg bone were found at the same place, and as they did not exhibit any appearance of having been water-worn, it was reasonable to infer the animal died near the place where they were found. They appear to be the remains of red deer, which tradition says were very abundant in the valley of Rossendale, which up to the time

of Henry VII was a royal forest. The short horn was found, along with several others, about a quarter of a mile higher up the valley, whilst sinking for a gas tank, and was probably the horn of a *Bos-primogenius*. Near the same place two antlers were found a short time ago, resting upon a loamy clay, under a bed of peat, 7 to 8 feet deep, near a spring of water, in a depression of the surface, where animals formerly resorted for the purpose of drinking. This hollow had subsequently been filled up to the level of the surrounding surface by the accumulation of vegetable matter, and this caused the occurrence of a bed of peat of small extent at this spot. One of the antlers is now in my possession.

Mr. Dickinson said peat was a wonderful preservative of things of this kind.

Mr. Aitken said he should like to have the opinion of the Society whether the short horn was that of the wild cattle—*Bos-primogenius*.

Mr. Plant said he thought there was no doubt it was the core of the horn of the *Bos-primogenius*.

Mr. Binney said it was a very small horn compared with others of the same kind found in the neighbourhood, some of which were thrice as large. His opinion was that they could not tell from a mere bone to what animal it belonged. To do that it would be necessary to see the whole of the cranium.

Mr. Plant said he thought the large bones should not be considered as fossils at all. Professor Owen did not acknowledge the red deer as a fossilized animal at all in England.

The thanks of the Society were unanimously voted to Captain Aitken and Mr. Ashworth for their contribution.

Mr. J. Parker presented some crystals of Selenite from the Trencherbone coal at Kearsley Colliery, near Clifton. The specimens were taken from the middle of the coal.

A clever imitation of a cast of a fossil fish was produced. A label affixed to the box said that the specimen was found near Desborough.

Mr. Dickinson—I believe the manufacture of flint implements has given a very profitable occupation to those who are clever enough to do them; but this is the first manufactured fish I have seen.

Mr. Binney—I have no doubt there are as many fossils manufactured as anything else if they can be found to pay. We shall have some fossil toads and frogs sent us next. I believe this specimen came from somewhere near Oldham.

A paper was then read—

ON THE

QUATERNARY DEPOSITS OF THE VALLEY OF THE MERSEY, NEAR STOCKPORT:

By W. R. Barr, F.G.S.

In opening this paper, perhaps I should say something with respect to the nomenclature which I have used in its title. The older geologists have divided the strata into three great divisions, namely, the Primary, Secondary, and Tertiary, but as geological knowledge increased, it was found that those later deposits which had by the earlier geologists been called recent, required some

more distinguishing mark of division than they had received by the early nomenclature. Post-tertiary was a name invented for them, they being that series of changes which have taken place after the close of the so-called Tertiary period. As is well known by the geologists of this Society, the Tertiary period closes with that great glacial and drift deposit, which is to be found spreading over most of the countries of the known world, and which has given us those large deposits of gravel, sand, and clay, with which we are so familiar. After the deposition of this formation it was generally thought that the earth assumed the proportion of sea and land which it now possesses, and that very few changes except those of the ordinary character, namely, the influence of the atmosphere and water in its various operations, had taken place; closer observation has shewn that the basis of this theory was incorrect, and that changes had taken place, and were taking place, that materially alter that system of *statu quo* which had been supposed to have existed from the close of the Tertiary period. Upheavals and depressions have been discovered in many countries within the historic period, and from many other sources we find that one or the other of these operations must have acted to place the strata, known as the Post-tertiary, in their present position.

It has been long felt by geologists that this part of the science has been neglected, and the research has not been brought to bear upon it which its importance deserves. But what can we expect? Can we expect persons to devote themselves to a part of a science which has not been thought worthy of a name by the enquirers that have gone before? But no doubt the principal reason for the neglect which has fallen upon this part of the earth's crust has been the familiarity with its phenomena which most men must have enjoyed, and geologists would rather ramble into more distant and perhaps more productive fields of research. I believe, if properly studied, that this neglected portion of the earth's history

will be found to yield a large amount of information, and give us some of those first beginnings or agencies by which the older rocks have attained their present form and structure.

Quaternary is a name given by the most recent geologists to that portion of the earth's surface which has not been already included in the other three great divisions, and for the reasons already given I am inclined to use it instead of the older and ambiguous one of Post-tertiary.

After this brief introduction, we will proceed to the consideration of the subject matter of this paper, namely, those Quaternary deposits which are to be found in the valley of the Mersey, near Stockport, not that there is any peculiarity of these deposits, over many of the same age in the different valleys which spread over this district and others, but that, as they have been my particular study, it is as well to localize them and draw general conclusions afterwards.

The Mersey and its tributaries, after making their way through the higher lands of Derbyshire and Cheshire, approach Stockport on the east, and after joining with the Tame, take a tortuous course between the high rocky lands on which Stockport on the one side, and Heaton Norris on the other, are built. The river at last emerges on the plain of Cheshire, west of the town. The narrow valley through which the stream runs is principally determined by the contour of the triassic rocks which form the hills on each side. Over most of the district these rocks are covered by a deep deposit of gravel and sand, and it is with these formations that we have more particularly to do, and which are the remains of that period which we have designated Quaternary.

On the high grounds on each side of the valley, may be traced the remains of the drift or glacial deposits, but in the valley itself

very few remains of its existence can be traced *in situ*, except these great beds of gravel and sand, generally known as valley gravels, can be taken, as no doubt they are, as evidence of its former existence. The till, which is a very distinguishing bed, and cannot be confounded with anything newer or older than the glacial period, may be seen on each side of the valley, especially on the easterly side of Stockport. Mr. Taylor found it on the Woodley Junction Railway, as described in a paper read before this Society, on the north side of the river, and it may be seen upon the other side in the steep banks which border the river along Woodbank and the Vernon Park. From these points it spreads over a large portion of the upper land, in the direction of Woodley on the one side, and towards Offerton on the other. This can be easily traced by the numerous brickfields which are scattered over these districts. No doubt it has also spread across the entire valley, and supplied the materials out of which the valley sands and gravels have been formed. If more careful research could be carried on, we should no doubt find it *in situ* in many places at the bottom of the valley. I have only been fortunate enough to find one instance, and that was last year in excavating for a new mill at the bottom of the valley, between the two high points already mentioned. After passing through the usual gravel mixed with beds of sand, we came upon a large mass of till, which was found to be about 70 ft. long and 7 to 10 ft. thick, resting upon the red rock, and evidently in its original undisturbed position. Although this is the only instance which has come to my knowledge, yet I have no doubt others must have been found, if we had any information concerning them, and no doubt others will be found if attention was more directed to them. It is not likely that we shall find anything except the clay, as the sand and gravels would be more easily washed away, or if we did find them, the difficulty of distinguishing between the older and newer formation would lead us to class them all under the latter head.

Our subject now leads us to examine the formations, which are better shewn, as far as I have been able to see, on the westerly side of the town. On this side of the valley the strata is of a different character, here we have three well marked terraces composed of gravel and sand, the river taking a course below the lowest, and carved out of the red sandstone rock either by its own agency, or what is more probable, following a crack or fault in the sandstone of much older date. The lowest of these terraces is generally composed of sand with few pebbles, and seems to be a continuation of the great Cheshire plane, rising along the upward course of the stream; at Cheadle Bridge, being about 100 ft. above the level of the sea, and at Brinksway about 130, the same plane may be traced at the easterly end of the town, where it reaches the height of 150 ft. It varies in width from about 100 ft. to half a mile, gradually widening out as it approaches Heaton Mersey on the one side, and Cheadle on the other. The continued and quiet deposition of this bed can be shewn by a stratum of fragments of coal which can be seen in several places along the banks of the stream, between Brinksway and Heaton Mersey, and inland at the railway cutting for an occupation road, about 300 yds. from the river bank, near Under Bank Farm. The same bed of coal I have traced on the easterly side, in the excavation for the mill before mentioned. It was in this bed that I found the shell (*cardium-edule*), and which I mentioned to the Society on a former occasion, but I have not found or heard of any other remains that would conclusively stamp its marine origin. The next terrace rises abruptly from the latter, but instead of being composed of sand, it is formed of a very coarse grained gravel, with round pebbles of from a very small size to larger ones, sometimes weighing as much as two or three cwt. The top of this terrace is a table land, of varying width, but about 170 ft. above the level of the sea. The third terrace, which at this place rises more gradually from the second terrace, than the second from the first, is entirely of sand as far as I have been able to trace it. The top of this forms

the high lands through the most part of Stockport, and stretches out to Brinksway Bank on one side of the river, and Heaton Mersey on the other. Its general height is from 220 to 250 ft. above the level of the sea. These terraces form the present contour of the country, but it would not be much different if the underlying triassic rocks were laid bare, as they are seldom more than 10 ft. below the surface, although they do not follow the abrupt transition of the terraces, yet they come into close proximity to them; their surfaces, where I have seen them exposed, are water-worn, and must have been at some time exposed naked to the action of the elements.

I have now put before you the geological facts which are to be found in examining these upper deposits in the district now under consideration, and it will be now our task to look at these facts, and try to form some idea of the causes of their formation. In doing this I may differ from some well known authorities, but I am sure that they will take my remarks in the spirit of true science, for if they can shew I am wrong, I shall be very glad to acknowledge my error, and if I am right, they will thank me for an advance of the truth in that science in which we are fellow workers.

In the first place, if these Quaternary deposits are the result of the action of the present river, and there has been, during their formation, no change in the level of the land, then, I think, we must look for a larger stream of water which could extend over a wider area, and exercise a greater force than the present river is capable of. Now as the waters of the Mersey are a collection of the rain fall of that district, which lies on the west of the great carboniferous limestone district of Derbyshire, to suppose that the area from which the river derives its water was increased, we must believe that these mountainous chains have risen since the glacial period to their present elevation, and that the waters of a much

larger district have poured their outfall into the present valley of the Mersey. I think the supporters of this theory will scarcely be inclined to sanction this view.

The next point to which I wish to call your attention is the elevation of the land through which the Mersey runs. If we start at Burfoot Bridge, the place where the Bridgewater Canal and Bowdon Railway cross the Mersey, the banks at each side of the river are only 75 feet above the level of the sea; from that point the land gradually rises until at Didsbury Corn Mill, the banks are 100 feet above the sea level,—a rise of 25 feet in about four miles. This lower terrace continues, as I have said before, through Stockport; at Brinksway, on the west side, it rises to the height of 130 feet; and at Brimington, on the other side of the town, to the height of 156 feet,—a rise of 56 feet in about another four miles. Although this terrace is not quiet flat, yet it nowhere, that I know of, rises to an elevation above 150 to 160 ft. The next terrace at Brinksway is generally 170 feet above the sea.

The third and highest terrace rises to the height of 225 feet at the same point. This last runs into all the high land in the neighbourhood, rising very close to this place to 233 feet; at Christ Church, near Heaton Norris Railway Station to 250 feet, and continuing through Reddish on the northern banks of the Tame to near Denton, rising gradually to the height of about 280 feet. The land on the other side of the Mersey, and also that which divides the valley of the Tame from the latter, rise to similar heights; the height above the level of the sea at Woodbank, the highest part of Stockport, being 276 feet, and near Offerton 284 feet. But on these highest levels we find generally the remains of the drift and glacial deposits which have not been washed away by subsequent denudation.

After laying down these facts it will be necessary for us to

enquire whether they lead us to any conclusion as to the age
which have been at work to cause these more recent forma
If we first of all remember, that during the deposition of th
and gravels of the drift period, the whole of the surface of
country must have been under the sea, and that the drift
have been deposited across these valleys as well as upon
higher ground in which we now find them, we can naturally
pose that if the elevation of the land had taken place sudd
that we should have found the till and other strata of this de
somewhat in the same relations as we find them on the hi
surfaces, except where they had been removed by the agenc
river or atmospheric action. But it is not likely that this el
tion took place so suddenly, and I think very few geologists wil
inclined to support a theory so adverse to all our known evid
of geologic changes. That the alteration of level would be grad
and that all the influences of that gradual upheaval may be tra
I think, in the different Quaternary deposits we have before n
tioned. Suppose we try to paint to ourselves the change wh
such a theory as this would bring about. The great glacial pe
is coming to a close, by some means which it would be very h
to trace, but most likely by the upheaval of land that has been
receptacle of all the mud, boulders, and sand of these great
rafts; a warmer climate now prevailed, and upon the land
reclaimed from the sea would spring up a vegetation, mor
accordance with our present flora than perhaps any that had g
before; but still a great expanse of sea would stretch over wha
now dry land. Most of Cheshire would be under water, with h
and there a green island studding its surface. The southern
of Lancashire, and the high lands about Stockport, would for
muddy or gravelly beach, indented by estuaries stretching far i
the land, the constant ebb and flow of the tide would soon dist
the deposits of the last epoch, carrying the muddy particles far
to sea; the sand would travel a less distance, most likely be
swept into the quiet nooks of the coast and there deposited in l

sandbanks; the gravels would keep nearer home, and out of these materials, sorted according to the strength of currents, would be formed the bed and beaches of this retiring sea. The elevation of the land proceeds, but not in constant ratio, for there seems to have been pauses in which the sea has had time to rear such masses of gravel on its beaches as to defy its action in after time to remove. Last of all, before the salt waters bade a long and last farewell to the valley of the Mersey, at Stockport, its tides must have rolled over a long and flat sandy beach, but even yet reaching far up into the land, and long after the last tide rolled up this valley, there might have been seen, from its high lands, the not distant sea, dashing itself upon its sandy shore, as if enraged at having lost its old habitation. But as the ages roll on, the sound of these grow fainter and fainter, and at last cease for ever. For ever! we can scarcely say, for it may yet come back again; the same cause, acting in another direction, may just undo what we have described as having been done. These changes, too, may not be of a very old date. There are many curious unsolved mysteries about this country in which we are living. Why was not Liverpool a port instead of Chester, in the time of the Romans? And when we are told by Mr. Geikie that the land on which the ends of the wall of Antonine, at the Firth of Forth and Clyde were built, are this day 25 feet above the sea level at high tide, shewing an elevation of the land, since the occupation of the Romans, of fully that height; we may not have to look many centuries back for the time when Cheshire was mostly covered with water, and when it would have appeared more likely for Manchester or Stockport to have been the port of these districts than Liverpool or Chester.

In conclusion, as I said at the commencement of this paper, I have no wish to dogmatise on this matter, I only put forward these views as they occur to myself, as the best explanation of the phenomena which have come under my notice, and that I may

elicit the opinion of others who are better able to judge than I
I think the subject of some importance, and worthy the atten
of those persons who make geology their particular study.

The thanks of the Society were unanimously voted to Mr. E
for his paper.

The President—It is generally supposed that the terraces h
been formed by the river. In the valley of the Irwell there ar
number of them, supposed to have been formed in this way.

Mr. Barr—As to the valley of the Mersey, I cannot see
reason to suppose that it is the present river which has formed
terraces. Mr. Binney, I believe, thinks that those in the Irw
were formed by the river.

Mr. Binney—No; I said large bodies of water; I did not
rivers particularly. I said nothing about the nature of the wa
If it is required for the sake of hypothesis to take the sea up th
by all manner of means take it up. All I hold is, that a gr
amount of water has gone down there. I should have liked
Barr's paper better if he had not brought us a new name, becau
when not wanted, new names are not of much use. They
it post-tertiary, pleistocene, and valley gravel, the last term f
used by me above 20 years since, and I do not see why Quatern
is required. These terraces are exactly what we see in the vall
of the Irwell, Dee, Lune, Ribble, and Eden. All the west riv
have the same kind of terraces, and they go to greater elevatio
These valley gravels go much higher in Rossendale, but t
get lower at Bury and Clifton, and towards Manchester,

lower still near Runcorn. If we look at the contour of the country it is very clear there must have been at some time a body of water in some state, either from the sea or land, which filled the spaces which have been described. Take a section of the Irwell, towards Salford and Pendleton, and you will find the same kind of features. Some of the sand described by Mr. Barr, I should hardly take to be valley sand, but the sand above the till. As you go up these valleys, for instance the valley of the Goit, there are a lot of little tributaries to be seen. In Fogbrook there is a great deal of gravel, and some little terraces. It seems to me that we must admit the former existence of a volume of water that would scoop out of the older drift deposits the whole of the valley, for that had been excavated previously, or else you could not have these valley deposits now found in it. The valley of the Irwell for certain has been, because under the valley gravel you find whole beds of till. In all our rivers on the west side of the country the salt water used to flow up a great deal further than it does now, even in historic times.

Mr. Greenwell—Is there any evidence to show that saddle does exist, or that that terrace at 172 feet does not continue through the hill?

Mr. Barr—No, most distinctly, because they work the gravel right down to the red rock, and it seems to continue above it.

Mr. Binney—I can answer that question with regard to this neighbourhood. At Stony Knolls you have a second terrace like this, and you see it resting on the side of the till, clearly proving that it has been eroded out of the till. At Brindle Heath, near Pendleton, they work out the gravel in the same manner, and expose the till on the side and under it.

Mr. Dickinson—As I take your paper, your view seems to be

that these terraces have risen from the country having been heaved.

Mr. Barr—Yes, during their formations. The whole of this been under water no doubt.

Mr. Dickinson—What, during the formation of the Quatern deposits, and after the formation of these lower beds?

Mr. Barr—Yes.

Mr. Dickinson—Such an upheaval as 172 feet must have b caused by some subterranean force. Can you give us any ic how it has been exerted. Is it from the lower measures, or o near the surface of the earth?

Mr. Barr—Geologists have not found out what the real cau are, but they have only found out facts, without knowing whet they were caused by volcanic or chemical agencies.

Mr. Dickinson—I should like to know how these upheavals t place. Sometimes there are great faults, and no indication wh ever on the surface.

Mr. Barr—Faults can only occur where there is an unequ elevation or depression of the strata. If there were a gene rising of the whole strata no faults would exist, and if it be a v gradual movement, like a great many of the upheavals we kn are taking place at the present time upon the earth's surface, would not be likely to have created faults.

Mr. Plant—If we take the whole of the western side of t Penine chain we shall find they are penetrated by faults of

similar description. Wherever the water has drained from the high land there are sure to be valleys along the course of the water; and whatever elevation is found at Stockport, would be found also in Manchester, and further north, and even further south of Stockport. The whole country must have been subject to this elevation or depression during the period it would require for the formation of these different terraces. They are not local phenomena at all, but belong to the geological features that pervaded after the formation of the great till deposit. I do not see anything wonderful in a river terrace being 172 feet above the level of the sea. It might just as well have been 300 or 400 feet. I did not very clearly understand about the specimens and shell mentioned in the paper.

Mr. Barr—It was only one shell.

Mr. Plant—I think the evidence of only one shell is too poor to be referred to a marine origin.

Mr. Binney—If Mr. Barr could find in the same place fragments of other shells it would give us more data to go upon. With regard to these terraces, as Mr. Barr's paper is confined to the valley gravels, I will not travel out of the course which has been laid down, but I see no difficulty at all about any rising of the land. Sir Charles Lyell has shown us (and given us evidence to that effect) that the whole coast of Norway is gradually rising. Mr. Darwen has also shown us the coast of South America has risen in recent periods for 1,500 or 2,000 miles. There are the old sandbanks and beaches left, and nothing is better established than that immense masses of the earth's crust are silently and gradually rising. I think it very probable there may have been changes of level right away from the north side of Scotland to Land's End. But I am not an advocate for raising the land on

every occasion it is thought desirable to account for phenomena. That great changes have taken place in recent times no one who has investigated the subject can for a moment doubt.

After a conversation relative to some chalk tracings on a black board which had been used during the discussion, the meeting closed with a vote of thanks to the President.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 16.] VOL. IV. [Session 1863-64.

The Monthly Meeting was held in the Museum, Peter Street, on Tuesday, May 31st, 1864.

ANDREW KNOWLES, ESQ., the President, in the Chair.

The President said he had received a letter suggesting that the proposed summer excursion to Llangollen, in conjunction with the Midland and Dudley Geological Society, and the Liverpool Geological Society, should be undertaken.

After a slight discussion, Mr. J. E. Forbes, the Secretary, was requested to communicate with the Liverpool Society, so as to be able to state definite particulars at the next meeting.

Mr. Forbes read a letter which he had received from Mr. O. A. Ferris, of the Victoria Park School, making the Society a present of a raised map, in plaster, of the High Peak of Derbyshire, coloured, to show the strata. The map was the work of the late Mr. Elias

Hall, of Castleton, who both moulded and coloured it, and took a great interest in the Society.

On the proposition of Mr. Dickinson, seconded by Mr. Good a vote of thanks was unanimously passed to Mr. Ferris for gift.

Mr. Goodwin presented a specimen of *Lepidodendron*, taken fr the Cannel Mine, Haughton.

Mr. Plant exhibited specimens of fish-remains, and portions o Crustacean, found in the coal-shale, at Bradford, near Manchest also a specimen of a plant (*Aunnlaria brevifolia*,) found in purple shales at Collyhurst.

Mr. Parker said he had previously seen some specimens fou near Manchester.

Mr. Dickinson said, if so, they were very rare.

Mr. Horsfall presented a large stone found in the Black Mi The specimen he said was the largest he had ever seen or heard

The thanks of the Society were given to Messrs. Goodw Plant, and Horsfall for their donations.

The following paper was then read—

REMARKS ON THE

SUBSIDENCE OF THE SURFACE, CONSEQUENT UPON THE WORKING OF COAL MINES:

By Joseph Goodwin, M.E.

The subject under consideration is one possessing some importance wherever coal-mines are worked, but in manufacturing and densely populated districts, it possesses an importance second to that of no other branch of mining engineering. Yet the most simple and obvious laws are often overlooked by those whose experience alone ought to render them familiar with the general principles bearing upon the subject. A few years ago, a case came under my own observation where two gentlemen of considerable experience as consulting mining engineers, arranged for leaving a quantity of coal for the support of a gentleman's residence. The quantity left was more than sufficient for the purpose, providing it had been left in a judicious manner, but instead of which the coal was left directly under the building and for about 20 yards on all sides, the depth from the surface was about 180 yards, the angle of inclination about 28°, the result was, more mischief was done to the mansion than if the whole of the coal had been worked out. When the occupants had quitted the premises, and all the mischief had been done that could be, an attempt was made to work out the coal that had been left, some of which were got, but at an expense far more than the value of the coal when raised to the surface.

I have not selected the above case in consequence of it being the worst I am acquainted with, but simply because the want of judgment was displayed by those who ought to have thoroughly understood the subject, and from whom no excuse of the want of early scientific training could be offered. I grant that the system of working coal, the nature of the strata overlying them, and the angle of inclination of the seam and its thickness, exercises

considerable effect upon the laws regulating the subsidence of the surface, and should therefore be disposed to make allowance for those who have only witnessed the effect produced in any given locality, or by any one system of working, providing the means of observation were less numerous. Under any system of working the surface must necessarily be lowered, but that can be effected without much damage to any particular building, providing we can change the direction of the breakage line, or render it so slight as to minimize its effect. By the term breakage line, I mean the point at which the subsiding surface separates itself from that which remains undisturbed.

In many cases, the breakage line is so well defined that it is very easy to trace it along the surface for hundreds of yards. I have occasionally seen the surface rent asunder to the extent of six or eight inches, and the subsiding portion lowered sixteen or seventeen inches along the line of the rent. From this it is easy to understand why some buildings should be injured much more than others, when apparently subjected to the same cause. In ordinary buildings the injury is so slight where the whole can subside together, that it is only the breakage line that we have to guard against.

In working mines at a high angle of inclination, the breakage line is much better defined than in mines at a low angle, providing the depth from the surface and other circumstances are the same. Whatever system of working may be employed, the breakage line invariably extends over the solid coal upon the deep of the workings. Suppose we adopt the long-wall system, and work out the coal from the shaft towards the boundary, we may expect to find the breakage line upon the deep of the workings, parallel with the line of level; but independent of this breakage line, there will be others running in the same direction as the face of the workings, which in many cases will be nearly at a right angle from the line

of level. For our present purpose we will call these cross-breakage lines; they occur much more frequently in working seams of coal that has tender strata overlying them, than where the strata is strong. In some cases they do not occur oftener than each four or five hundred yards, while in others the distance will not exceed fifty yards. These cross-breakage lines are not so well defined as those which run parallel to the line of level, nor is the effect produced upon buildings so great.

In eighteen cases that have recently come under my notice, the cross-breakage line has been at an angle of from 5° to 7° from a vertical line extending over the solid coal, the circumstances under which the observations were made differed in each case. To guard against the effects of these cross-breakage lines, it is therefore necessary to use precautionary measures at least twenty-five yards before approaching any building or other works which may require protection, providing the seam of coal that is being worked is at a depth of two hundred yards from the surface. Where the long-wall system of working coal is employed, and the roof well packed with the debris of the mine, the subsidence takes place with far greater regularity and less violence than if the roof of the mine was left unpacked or the pillar and stall system adopted.

I have a case at point where five separate mines have been worked from under certain buildings, at depths varying from 70 to 250 yards, without producing any perceptible breakage of the walls or materially affecting the buildings in any respect. Yet the houses and land upon which they are erected have been lowered a distance of more than 10 feet. The houses are ordinarily built three storied ones, and being within a few yards of the banks of a canal, good opportunity is afforded of measuring the exact distance that the land and buildings have been lowered, inasmuch as the original level of the water must be maintained. It is not only buildings that are disturbed by the subsidence of the surface,

but a variety of other things, some of which are more sens
than buildings, or even delicate machinery. I am not awa
anything that is more easily affected by the subsidence o
surface than the pipes used by the various water works comp
for conveying water for the supply of large towns, more espec
so if they are subjected to a considerable hydraulic pres
which must necessarily be the case in hilly districts. Some
ago the Manchester Corporation Water Works Company
much alarmed at the very frequent derangement of their pip
Haughton, and purchased a quantity of coal to prevent a fur
disturbance of them. In this case I have seen the same jo
repeatedly broken without being able to trace the slightest e
upon buildings situated at a distance of only a few yards. If
coal are worked upon the principle of pillar and stall, the brea
line will extend over the solid coal as in the case of working
the long-wall system; but the cross breakage lines will be fo
to be much more irregular and difficult to trace, yet the e
produced upon the surface is decidedly greater. There are sev
circumstances, all of which contribute to produce the differ
spoken of, such as the irregularity of the face of coal when worl
out the pillars, and the pillars of coal that are left unwrou
through defective management. The quantity of coal that
irrevocably lost every year through the last mentioned caus
almost beyond belief, and instead of being productive of good
preventing the subsidence of the surface, it causes the same
of surface that would subside together to be broken up i
different parts, thereby causing additional breakage lines,
increasing the danger to property.

The foregoing remarks will apply to all other methods
working coal; in fact there are only two systems, for all others
either a modification of the pillar and stall or the long-wall,
combination of the two. I entertain different views than m
upon the propriety of leaving coal for the support of cottages

detached houses, or other buildings. In many cases the lessee may make good the damage done to buildings at one half the amount of the loss that he would suffer by being deprived of getting the coal, upon which the expense of sinking shafts, erecting machinery, &c. has been incurred, while the lessor is deprived of rent that would in many cases purchase the property, or rebuild it if razed to the ground. I have known thousands of pounds worth of coal left for the support of buildings over and above the value of the property which it was left to support. Supposing, for instance, we are desirous of supporting a single building, twenty yards square, it would be necessary to leave one half of the coal for seventy yards upon the line of level, and sixty yards upon the rise and dip. If only two mines are being worked, of an united thickness of ten feet, the mine rent of the unworked coal, at a shilling per ton, and computing twenty-nine feet to the ton, would be £325, setting aside the profits of the lessee, which ought to be taken into account, as well as the expense of sinking shafts, erecting machinery, and driving the narrow work through the left coal, the extra expense of getting the coal, and the increased proportion of small coal, which invariably attends the extra cutting of it. Independent of the pecuniary loss already considered, there is also the loss to the nation and succeeding generations, for the coal left for the support of buildings &c. must in almost every case be considered as irrevocably lost.

Yet such is the state of the law bearing upon the subject, that if the owner of surface property chooses to demand an exorbitant sum for any damage that his property may have sustained, it becomes a matter for serious consideration whether it is not better to rest satisfied with the exaction rather than seek redress in a court of justice. Nor is this the worst feature of the case, for as the law now stands, the capitalist who has been bold and enterprising enough to employ his capital in the working of coal mines shall be held amenable for any injury caused to any building,

machinery, &c. on the lands of an adjoining proprietor, "providing such buildings have not been erected thereon, or enlarged, within twenty years, and that the said buildings did not either contribute to or occasion such subsidence." This decision applies whether the mines have been skilfully worked or not, or whether the coal has been wrought immediately adjoining the point where the subsidence takes place. It is therefore essentially necessary that we should possess as much knowledge upon the subject as possible, so as on the one hand we should not leave a greater quantity of coal than is absolutely required, nor on the other expose the capitalist to unnecessary risk.

I have before stated that the breakage line is invariably upon the deep of the workings, and will now endeavour to point out the rules by which its direction can be determined, and also the most advantageous principle of leaving coal for the support of buildings, &c. The rules that I shall lay down have been arrived at from careful observations, extending over many years, and made under a variety of circumstances, and will be found to apply to all mines of from 4 feet to 6 feet in thickness, with strata of an ordinary character overlaying them. I have thought it best to put them in tabulated form, giving the angle of inclination, depth of the seam from surface, the distance of the breakage line from a vertical one, and the angle of the hypothenuse, or breakage line, measuring from the angle of inclination of the seam. In giving the angle of the breakage line I have taken the fractional part of a degree only, as being near enough for all practical purposes.

Angle of Inclination of the Seam.	Depth of the Seam from surface.	Divergence of the Breakage line from a Vertical one.	Angle of the Hypothenuse, or Breakage line.
Degrees.	Yards.	Yards.	Degrees.
10	240	72	96½
15	196	68	93½
20	216	76	89½
24	240	86	85½
27	176	70	84½
31	204	91	83
34	250	104	78½
40	198	96	75½

The breakage line of mines, with a strong strata overlaying them, is not at so high an angle as when the strata is of a tender character. The difference, however, is not so great as is by some supposed. I have on different occasions carefully made observations, and the conclusion that I have arrived at is, that between the strongest and the tenderest strata the difference in the breakage line does not exceed 5°, providing the thickness of the seam and other circumstances are the same. The thickness of the seam doubtless exercises considerable effect upon the subsidence of the surface. I should consider that in working out a seam of coal 4 feet in thickness, under ordinary circumstances the surface would be lowered 3 feet, providing the depth from the surface does not exceed 180 yards. This proportion is maintained in thicker or thinner seams at like depths, but the effect gradually diminishes the deeper the seams are from the surface. I do not suppose that the mere thickness of a seam exercises any effect upon the direction of its breakage line. It is considered by many that the breakage line is always at a right angle from the angle of inclination of a seam, but those who hold this view would do well to make careful observations in mines laying almost horizontal, and also at a high angle of inclination. Sometimes all calculations are set at defiance by the subsidence draining a quicksand, or by the water being drained from old workings, but these are exceptional cases, and can only be partially guarded against by carefully watching the effect upon buildings, &c., and binding them together by means of rods of iron, or using other measures to lessen the effect so soon as any disturbance shall be perceived. In leaving coal for the support of buildings, &c. it is quite clear from the foregoing remarks that both a sufficiency must be left, and left too in a proper manner, or no good can result from leaving it. Were I leaving pillars of coal for the support of buildings, &c. I should be governed to some extent by the cleavage of the coal. If the cleavage was nearly at right angle with the line of level, I should prefer leaving the pillars parallel to the line of level; but if the

cleavage is nearly in the same direction as the line of level, I should leave the pillars at a right angle with the line of level. If working two seams, I should leave the pillars, in one of them at a right angle with the line of level, and in the other parallel to it. The pillars should always be left upon the rise of the buildings, &c. requiring protection. The proportion of coal that it is requisite to leave depends upon the nature of it, as well as the stratum upon which it reposes. Some seams of coal are so tender that it would be unsafe to work out more than four-tenths of the seam, while in others it would be quite safe to work out one half of the coal, exclusive of the openings between the bords, or bays, which it is necessary to make for the purpose of ventilation. It is often convenient when leaving pillars of coal to remove the refuse from other parts of the mine into the space from which the coal has been wrought; in doing this care should be taken to put the refuse in such a position as to give the greatest support to the roof of the mine. The breakage line may occasionally be found upon the rise as well as the deep, but that can only be on removing the first rack of coal, or where the subsidence has only partially taken place, owing to the limited area of coal that has been wrought.

I had intended to have offered some remarks upon the effect produced upon seams of coal by working the under mines first, but find that I have already exceeded the limits assigned to myself, and must therefore leave that portion of the subject until some subsequent period.

On the motion of Mr. Dickinson, seconded by Mr. Horsfall, a vote of thanks was given to Mr. Goodwin for his paper.

Mr. Greenwell—This is a very interesting subject, and one

which is constantly being brought practically before every one who is connected with collieries. The paper is a very able one; and the first thought which strikes me is that the position of the line of cleavage described by Mr. Goodwin has reference more directly to coal worked by long work. There must be evidently two different laws followed in case of fracture where coal is worked by long work, and by pillar and stall work. For instance, when you are taking the whole of the coal out, you are leaving the whole mass of strata to form its own settlement without in the first instance forming small breakages—forming pillars so to speak, upon which the upper strata as a mass may rest. It is perfectly clear if you remove 30 or 40 square yards of coal, and get a fall of stone, the bulk of the broken stone being of course so much greater than the bulk of the compact stone, it will sooner or later form such a pillar for the superincumbent strata to rest upon as will prevent any surface subsidence of the smaller portion. There must naturally be a different law followed when the work is done by pillar and stall system to that pursued with long work. I have seen surface subsidence where thin seams have been worked, as described in this paper, but I have also seen very large districts worked by pillar and stall where there has absolutely been no settlement, and in other cases where there has been. The general law is that where you take out coal by long-wall, you will have surface subsidence, but it does not appear to be so general in the case of board and pillar work.

Mr. Horsfall asked to what depth was it supposed the surface would be affected by working out a seam of from four to six feet.

Mr. Goodwin—I was just going to ask Mr. Greenwell at what depth it ceases to affect the surface? I have recently seen a case where the surface has been affected with working a seam at a depth of 680 yards. If you go to a great depth of course you do not see the same effect as at 200 yards.

The President—When you state that the subsidence caused by a mine four feet thick was three feet, what allowance was made for the packs?

Mr. Goodwin—I gave three feet as being the maximum in case the pillar and stall system was pursued.

The President—Did I understand that when the subsidence takes place there are underground caverns formed, which prevents the appearance of it on the surface?

Mr. Greenwell—If you take a solid yard of coal, or stone, and break it up from its solid state into fragments, of course it occupies much more space than it did before. It forms a sort of artificial pillar, choking up the space, and preventing that subsidence which takes place in the long-wall system of working. Where you have these repeated breakages, and filling up with broken material, you do not have that settlement of surface which you have when the long work is practised.

The President—But is it not known in practice that the enormous weight and pressure make an appearance on the surface?

Mr. Greenwell—Very numerous instances indeed I have seen where, in the pillar and stall method of working, this subsidence, particularly at large depths, is the exception and not the rule. Where long work is carried on the subsidence is the rule, not the exception.

Mr. Dickinson—In November, 1859, I gave a paper on this subject to this Society, which is printed in our Transactions. The observations which I made there had been arrived at after many years' experience, under a large number of opportunities of making my observations. Since then I have had many other

opportunities of making similar observations, but they all tend to confirm what I then stated. This Society is exceedingly obliged to anyone who can bring their experience to bear upon this subject. The very fact that there should be difference of opinion to-day amongst gentlemen who have had innumerable opportunities of forming an idea shows that there is a diversity of sinking to be observed in different strata, and that some conclusions must have been drawn of strata of one degree of hardness and tenacity, and others from another degree. There were some mining engineers who considered that when a depth of 600 yards had been reached no further observable subsidence takes place; and that at a depth of 200 yards a four feet seam would sink the surface about three feet, This I heard stated in evidence by Mr. George Elliot, a mining engineer of considerable experience in this country. When I wrote the paper to which I have referred I did not concur in that view. I stated that in my opinion if the coal were all taken out the sinking would be only a matter of time, and that if the intervening strata were much broken the settling would be less, but still it would only be a question of time. In regard to the broad fact stated that at 600 yards no sinking would take place, I have myself within a few months had actual demonstration of a sinking at a depth from a little under to over 600 yards, and that by the ordinary system of working our Lancashire mines, which is a mixture of the two systems of working. The sinking is plainly observable across a grass field, and some of the cracks are so large that I have put my foot down into them. The evidence of Mr. Elliot, to which I have alluded, was given in reference to the Liverpool Water Works, when several engineers of great eminence were examined. Mr. T. E. Forster then stated that at the St. Lawrence Collieries the works were stopped at 80 yards beneath the side of the river Tyne, the proprietors of the adjoining collieries having petitioned the Corporation to that effect. Other instances of the same kind were given. In the reading of a paper like this it is very difficult to catch each point, and I did not quite notice

whether Mr. Goodwin said that the sinking was invariably to the deep of the work.

Mr. Goodwin—The breakage line I spoke of, as being invariably upon the deep of the workings. Sometimes a breakage line is also found upon the rise; but this can only be caused by partial subsidence on working a previous rack of coal, or it being the first rack of coal worked.

Mr. Dickinson—In my paper I go into that subject, and take it where there is no dip to be dealt with, and in that case we find that the breakage line is not a vertical one, but extends beyond the area of the coal worked out in the seam. Such being the case, it depends upon the angle of inclination how far this breakage line extends over. If the angle of inclination be only slight, the breakage line will extend to the rise of the mine. Even in Lancashire I have seen cases where, with the strata dipping at the rate of 1 in 3½, the breakage line has extended to the rise of the coal. If any gentlemen have observations to make upon this point, and would favour us with them, it would be well, for this is a matter of great importance in a county like this, where the surface is overspread with buildings and hydraulic works. From the numerous advantages I have of witnessing the different systems, I am able to form a slight opinion. Formerly the common way of leading the pillars to the support of the surface was to leave a certain proportion of pillar—say to work out 4 yards and leave 4 yards alternately. But now the favourite way is to leave the pillars in larger blocks, and take away a larger space; in other words, taking out 20 yards, and leaving, say as much as from 20 to 40 yards There are actual workings where two-thirds of the coal are being sacrificed solely for the support of the surface.

Mr. Peace—We find near Ashton that at 150 yards deep the coal got out of a four feet mine—the angle of the mine being about 26 degrees—breaks over 134 yards, 60 yards of drift overlays

the coal-measures; and it not only breaks over on the deep, but on the rise, and 40 yards above where any coal has been taken buildings have sunk. At the present time we have some difficulty in ascertaining what proportion of the coal we shall leave for the protection of the buildings. We are busily engaged in making experiments, and in one portion we have taken out five yards of coal, and leaving seven, which we think sufficient to support the many buildings which are upon the surface.

Mr. Greenwell—Another point is as to the leaving of narrow pillars, and taking, say five yards of space, and leaving five yards of coal. Of course a great deal depends upon the state of the lower earth. If the under earth is soft, the same subsidence may take place on the surface, but in a different way, by pressing these pillars into the floor, causing what is called a "creep," which shews itself by the rising up of the floor between these pillars. But the simple fact is not so much the rising of the floor, as the pressure bearing these pillars down. Thus it is the pillars settling instead of the floor rising. You may therefore eventually have the same settling of the surface by leaving these smaller pillars as if you took the coal out. The whole of the village of Wallsend was settled down four feet in this way.

Mr. Goodwin said that he thought there was sufficient data to warrant him making the statements he had made, the law he had laid down was considerably proved. He quite agreed with Mr. Dickinson that under some circumstances there was a breakage line on the rise.

Mr. Dickinson said if the pillars were left in such a way as to allow of any breakage line running underneath a building it was more damaged than if the coal were worked out entirely. It had in many instances been observed that it was found best, where the property was of a description which admitted of being lowered, to work out all the coal entirely, and to allow it to settle down.

The President asked where these circumstances would be altered by the existence of quicksands.

Mr. Peace said in his case the earth was pretty solid, and they had drawn off a good deal of water, but had not gone through any serious quicksands in the sinking.

The President—So far as leaving pillars are concerned, I think decidedly it is best to leave them very large if you have to leave them at all. So far as regards damaging a building by working the coal, I think the damage almost invariably arises from part of the coal being got, and the other left, thus breaking the back of the building. I have known a case where one half of the building was very much damaged, and it was put right. Afterwards, when another portion of the coal was got out, it altered back again. I am convinced the damage chiefly arises in this way. It is quite unnecessary in getting coal under a valuable building to make arrangements that all the building should come down at once. I have known cases where buildings and land have gone down, and the people on the surface have known nothing at all about it.

Mr. Peace—I have seen frequent cases where part of the building has been damaged, especially in the case of cottages. I have requested them to let it stand, and it has gone back again to its original position.

Mr. Dickinson—It may be information to some of you to be informed that where ranges of water pipes go over, it is now being proposed to work out the whole of the coal underneath the centre portion of the range, beginning at first to leave large pillars, and gradually lessening till all the coal is removed, so as to let down the surface in curves, and thereby avoid breaking the pipes, or drawing the joints.

This closed the discussion, and a vote of thanks was passed to the President on his leaving the chair.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 17.] VOL. IV. [Session 1863-64.

At the Meeting held on the 28th June, the President in the Chair, it was announced that Captain Aitkin had presented a specimen of Pterodactyl to the Society.

A paper was read by Mr. E. W. Binney, which had been forwarded by Mr. John Warburton, of the Kingswood Collieries, near Bristol. The paper was as follows:—

COLLIERY ACCIDENTS:

BY JOHN WARBURTON, COLLIERY OVERLOOKER.

Accidents in coal mines are of such frequent occurrence that few persons cannot but be more or less acquainted with them.

In connection with all the industrial arts, the operatives seem exposed to risk of life or limb in some way or other—whether it be in the production or manufacture of material: but in no branch of equal extent is the operator more liable to accident than is the *miner*. From the time he reaches the pit's bank in the morning till his return to the same place, he is in jeopardy every hour and moment; and I think no one will dispute me when I say that *no* branch of labour is so prolific of attack on human life

and property as is that under the designation—*mining*. It makes one shudder to take a retrospect of those times when accidents were not known beyond where their effect was felt, and their causes never pried into, when, with the mining science of the present day, and the suggestions as well as the inspection of legally appointed mine inspectors, we have accidents taking the lives of nothing less than 1,000 individuals annually.

If the miner met with the accidents all in one shape he might possibly avoid them, but they come in so many different forms that the most familiar eye sometimes is unable to detect their appearance. A large number of individuals are scorched or burnt by fire-damp, or poisoned by the products of its combustion, others suffocated by black-damp, some killed by blasting powder, many by inundations, more by falls of roof, coal, sides, &c.; also by falling down shafts, by being run-over in inclines and main roads, by becoming entangled with the machinery employed in and about mines, by over-winding, by boiler explosions, and the ever memorable new Hartley accident, as one entirely out of course; it has not had a parallel, and very likely never will: others we can better call miscellaneous accidents. Allow me to remark here that, in addition to the death list, it is probable that not fewer than 2,000 persons per annum are maimed or wounded in such a manner as to cause intense suffering. I am not, in this paper, going to enter into *all* these different classes of accidents particularly. There are two out of them that are more common than the rest, by which more lives and property are lost than all the others put together; so that it is those with which we have most to contend (yet strange to say, least understood) that I purpose specially entering into.

Permit me, before proceeding farther to say, that what I shall adduce is not a new sprung idea, but has for some years been a conviction in my mind, and that, before now, I have advanced some of the ideas to the public. I have also requested discussion in the Mining Journals; and it is, that what I advance may be

thoroughly sifted, that has induced me to bring this paper before you. Knowing that opinions are "dry sticks" upon which to build anything that has to bear a test or stand opposition, I have taken some "facts and figures" from the reports of the Government Inspectors of Mines. Being aware also that there are individual years that record exceptional accidents, I have taken five years of the latest out, from 1858—1862, both included, which I think extends over a period that may be taken as a fair average. If I had taken six years, the list of explosions (which forms the principal one of my paper) would have been swelled by the "Lund Hill" explosion. The year 1863 also will show above an average of explosion, so that I think we may safely base some calculations upon the five years I have taken. I have said that, in connection with our collieries, there are some 1,000 lives lost annually; this is a large amount—yet true. The years from 1858 to 1862 show a total of 5,021, averaging for each year, 1,004, equal to 1-235ths of our mining population annually. Take the five years and we have them thus:—

1858	931.
1859	905.
1860	1,109.
1861	943.
1862	1,133.
Total	5,021.

Casualities by being run over, entangled with machinery and over-winding, are accidents that may easily be seen through. Those by falling into shafts, and debris falling down shafts, do not seem involved in any darkness—requiring precautions only that are well-known. Those by blasting powder, together with the products of its combustion, are more numerous than should be, yet I see nothing mysterious in the matter, though all due and necessary caution should be taken according to the circumstances under which blasting is required. Inundations also cannot be classed as mysterious; the cause is generally plain, viz., ignorance of position, &c. Explosions, falls of roof, &c., come under a different list, and are

amongst the number, or rather *form* the number set down behind the scene of *mystification*.

I have added the totals of the five years, and classified them as follows:—

Explosions.	Falls in Mine.	Falls in Shafts.	Miscellaneous Underground.	Miscellaneous Surface.	Total.
986	2006	846	907	276	5021

From these figures it will be seen that explosions and falls *in* the mine make a total considerably larger than the other three classes put together: thus—explosions, falls of roof, &c., 2,992; all the rest, 2,029; leaving a difference of 963 more in the former than the latter. Be it understood throughout this paper that, in speaking of explosions, I have *not* included those of powder, *i.e.*, lives lost by that come under the miscellaneous list.

Explosions of Fire-damp, or Carburetted Hydrogen.

I have no need here to enter into the chemical compounds of this destructive element. It has too long told its tale for anyone to doubt its *being* an element of destruction, both of human life and valuable property. We all agree thus far, because the effects of it are so frequently and forcibly brought before our eyes; but when I advance a step further, and look, and converse about the *cause** of this devastating agent, the point seems to dwindle away into a mystified conjecture and mere opinion. It is true there is now and then an explosion that can be seen through, but very few indeed in comparison with those rolled in obscurity. How many explosions pass away without the *real* cause of them being known, and without satisfaction to either parties interested, or the public. Have we not had much fault-finding, and much complaining of coroners' juries, because enquiries have ended without arriving at anything definite? That a cause exists no one would think to question: what remains is for us to get *at that cause*.

* I am not here bringing into question the properties of this gas, that I take for granted we all understand.

Government has issued its laws, and says, such and such must be done, and that is as much as can well be expected. Economy has opened its mouth and continues to proclaim against such destruction. Humanity speaks louder than either, and says, "brush aside the mist and see the core;" yet, notwithstanding all these potent appeals, dreadful and unaccountable explosions do take place. As we do not see the immediate cause of these accidents, let us look at what is *not* the cause, and that may possibly push us up into a corner from whence we may get a glimmer into what *is* the cause.

In all gas-producing mines it is advisable and economical to have firemen, in number according to the area worked, whose duty is to look for gas, and specially prohibit access to any place or places where such is found. Very rarely indeed are there any such places; generally all places are in a working condition—and so it really is—for very few of these accidents take place in the morning or commencement of a working day; all goes on pretty well till about one-third or one-half of the day's work is done—then an explosion takes place. Such an explosion cannot be said to be the ignition of *accumulated* gas; there is sufficient proof that none there was. Now what I should like to get at is this: How is it that most of these heavy explosions happen in the midst of a working day? That such is the case I think few will deny. Let each call to mind those that have occurred in his immediate locality, and see if a large majority has not been as I say. Call to mind the "Land Hill," in Yorkshire, which took place about twelve at noon, in February, 1857; one that happened at Tyldesley, in Lancashire, in December, 1858; Risca, in South Wales, did not come off first thing in the morning; Gethin, Myrther Tydvil, took place at noon; Lynishaw, at Worsley, occurred at noon; Edmond's Main I say nothing about; the Morfa, in South Wales, went off a little before noon: these, along with others which each of you may remember, seem to say that there is some *general* cause for this apparent uniformity, and our duty is to try to get at the root of it. Another very feasible feature presents itself in this class of accidents. Besides the particu-

lar time of the day, "King Fate" seems to make more havoc amongst miners during a *particular* season of the year, as if there were a season of the year and time of the day he was let run wild. Apart from the Hartley sufferers and those by blasting powder, I find the number of lives lost by explosions of "fire-damp" alone to be for the five years, 986, or an average yearly of 197·2. Of these I find they have taken place in the months of the years as follows:—

FROM 1858 TO 1862.

January	40	July	30
February	174	August	53
March	125	September	48
April	37	October	50
May	42	November	70
June	25	December	292
		Total	986

It will be seen there is great disparity in the numbers for the months. In order to see these figures better, I have divided them into periods, first, of three. Taking the first, second, and third four months in the year respectively, and we have them thus, 378, 150 and 458 standing in the following proportion:—the months January, February, March, April, 2·5; May, June, July, August, 1; September, October, November, December, 3. Or again, divide the time into two periods instead of three—beginning with October, ending with March for one, April to September the other—and these figures present themselves thus: 753 in the former, against 233 in the latter, or 3·23 against 1. Seeing this great inequality, all must admit there ought to be a corresponding proportion in the causes. If we could turn the figures round, and, instead of having 3 in the winter season, for 1 in the summer; have the 3 in the latter and the 1 in the former, we might have some plea, and thus partly set our minds at rest; but as the figures stand as they do, the matter must be dealt with.

It is a well-known fact amongst all classes of miners, whether illiterate or the more intelligent, that it is more difficult to keep up

the ventilation in summer months than in the winter. This is, of course, acknowledged by all acquainted with gases, and the cause plainly understood. The atmosphere being raised in temperature approximates that of the mine, and even goes beyond it—hence is the difficulty of maintaining an underground current. Yet we see that, during these disadvantageous months, not more than one person loses his life by explosions, against more than three in the six months more favourable to ventilation. By some this may be thought to be owing to extra production consequent on winter's consumption. It is to be regretted that the Mineral Statistics are not returned so as to be serviceable to me in this respect. If I took the exports, that would be far from the coal got or produced. In the absence of the amount of coal raised in the periods as I have taken the accidents, I might safely say, there is *not* that extra amount of coal produced so as to account for the proportion of fatalities. But I think I shall be enabled to lay before you figures that will serve as a guide in this respect. I think no practical man will disagree with me when I say that *no class* of colliery accidents is more *directly* influenced by the quantity of coal got than that of falls of roof, coal, &c. If this assumption is granted, we may look out for the same proportion of fatal casualties in the list of falls of roof, &c., as that of explosions. Let us take the number of accidents by falls of roofs, &c. in the same way we have taken by explosions, and we have the following:—

January	180	July	143
February	182	August	178
March	198	September	163
April	168	October	174
May	158	November	146
June	173	December	143
	1059		947

Total 2006

Divide these into two periods of six months each and we have these:

October—March, 1023. April—September, 983,

or 1·04 in what I have termed the winter months, against 1 in the summer; while the accidents by explosions stand for the same periods respectively—3·2 against 1. I have introduced this class of accidents here not to prove anything relating to them, but to show the great difference between them and explosions; and as before stated, there is no class that keeps up to the proportion of coal produced as does that of falls of roof coal, &c. From this then we deduce the following: that while we have for those accidents that keep pace with the amount of production 1 against 1·04, we have 1 against 3·2 for the same period, but under more favourable circumstances.

It is said by practical miners that gas is much keener in winter than summer—by some of the mining faculty that the gas is a compound of somewhat different elements; of the two I fall in with the former, for the reason that has been before given—the greater difference in the temperatures of the surface and mine: so that, where air-ways do exist, there is a sweeping current; where no air-courses are the gas is not much disturbed, consequently have more of the explosive element less diluted. I could see through an explosion happening first thing in the morning at this season (winter) of the year; but these are very few compared with those that take place later on in the day. And does not experience as well as the laws of physics teach us, that if the atmospheric pressure be diminished in the mine more gas exudes? Yet, strange as it appears, during the period we have the greatest atmospheric pressure, we have also the most destructive explosions—and these occurring as before said—generally in the midst of a working day.

There is room for the suggestion that the cause of these accidents may be a sudden out-burst of gas; this is an *unsettled question*, and always wrapt in uncertainty, and serves very frequently as a resting-place when other sources fail to support the scrutiny of inspection and inquiry. But suppose we admit this *hypothesis*: How

come these out-bursts to be so *regular* as regards time of the year and day?

I now leave this class of accidents for your discussion, and briefly review accidents by falls, &c., as bearing upon themselves.

ACCIDENTS BY FALLS OF ROOF, COAL, SIDES, &C.

As has been already stated, there are a large number of lives lost annually under this list. The total number for the five years under review is nothing less than 2,006, being an average yearly of 401·2. And although this is more than twice the number sacrificed by explosions, they pass away little heard of, consequently little attention paid them—less scrutiny, and no public contention as to their cause. This is, I suppose, first, because they do not come in that wholesale way explosions do, but by ones and twos at a time, causing no excitement beyond the immediate vicinity where such takes place; and second, because the uninitiated and non-practical public cannot at all see the way these misfortunes happen.

It is true, in the lecture-room of the geologist, the line of cleavage, &c. is spoken of, and its importance in mining operations shown but in its practical bearing, and in its *only practical* place—the mine—little is said or known of it. The miner knows when he meets with a "slip" or "face," but nothing more than the individual visible one thought of. I shall be free from exaggeration if I say I have seen thousands of tons of valuable coal lost through the want of this knowledge; and any person may easily conjecture the risk there is to life under such circumstances. Yet I have not met with half-a-dozen miners, including officials, possessing any knowledge of cleavage. I do not presume to say that these accidents are as manageable or as preventable as explosions; yet I think there is a something that warrants a closer investigation than is common in this class.

As I have before stated, there is not that great disparity in the months of the year that there is in explosions; but if this be absent there is a feature worthy of notice. I again refer to the time of the day at which these accidents happen, and ask each one of you at what time of the day those you have seen, which have occurred in your own locality? What time are most of you ready to exclaim? Not the morning, nor in the midst of the day, but at the close of a day's work; or when a person is remaining longer than an ordinary day at one time. I think you will confirm this, which is not a supposition, but the result of many years close observation on my part. I am not able to prove this by figures, as no record of the time of the day at which accidents of any class take place is kept. I think if we had a list in the reports of the time of the day that all fatalities happen, it would be of service by enabling us to compare one with another. Not that I entertain any such idea as to think any one hour out of the twenty-four is a more fatal hour than the rest—none such a thing; but I do entertain an idea that there is some *general* cause, which, if ascertained, we should be better able to ward off.

I leave this paper for your discussion, and shall only be too glad if it be the means of drawing out *the cause* of these deplorable accidents so common to the miner, yet involved in such mystery.

Mr. Chapman proposed a vote of thanks to the writer of the paper.

Mr. Goodwin seconded the motion, which was agreed to.

Mr. Goodwin—The paper is so voluminous in its character, that it would almost be impossible to separate each part and go into it

in detail; but we must all be impressed with the necessity of doing all we can to avoid those frequent accidents of which he speaks. It is a subject which has engaged the attention of most of us, and we are all desirous, as far as we possibly can, to avoid those accidents. But I have arrived at the same conclusion as many others doubtless have, that they are unavoidable to a great extent. Accidents caused by falls of roof must occur so long as mining operations are conducted; but it is possible to diminish the number, and I think one of the best means of doing so is to appoint persons who thoroughly understand the nature of the strata overlying the coal, to see that the posting of the roof timber is properly done. I do not see what other means can be adopted. In many extensive collieries in this district, each individual collier is left to set and draw his own timber, although he does not know the right way of doing so, and thus he endangers his own life and the lives of others. With respect to the time and season of the year when accidents happen, it may be remembered that, some time ago, I referred to the subject. I stated that at all times gas did not exude more freely under the circumstances it was supposed to do, and there was also a marked difference in the gas exuding, although the temperature was the same. I cannot ascribe any cause to the accidents occurring in the middle of the day as Mr. Warburton states they do, unless it is because the air becomes laden from the time the men have been at work with the carbonic acid from their breath. By the air being more thickly charged, the gas may find more difficulty in getting through. Some loss of air is also experienced by the frequent opening of the trap-doors.

Mr. Smith—As far as the carbonic acid goes, that would have the tendency to diminish the number of explosions.

Mr. Goodwin—That may be so in a laboratory, but if you go

into the question in the working department you will find the air sluggish, and not moving with the same rapidity; and therefore not capable of removing the gasses as emitted.

The President—It appears to me that Mr. Warburton gives the statistics, but does not throw out any suggestions by which the accidents can be prevented. He seems almost to take it as a matter of fact that they do happen, and will continue to happen. However, the absence of suggestions does not reduce the value of the paper he has contributed, because, I quite agree with Mr. Goodwin, that accidents in connection with getting coal will always happen. I believe the occupation of a coal miner may be compared to a certain extent to that of a sailor. Means may be found to lessen the causes leading to loss of life, and to prevent them to a certain extent. As far as my experience goes, and I have been down into mines hundreds of times in all parts of the kingdom, the wonder is not how so many are killed, but why there are so few, considering the many classes of accidents to which miners are liable, particularly from falls of roof. Connected with the working of mines ourselves, we do not look upon it as dangerous to set props or iron pillars for the support of the roof; but we look upon the particular danger in drawing them. The drawing of the supports is invariably attended with a considerable amount of risk, and that is the reason why we place those men who are considered competent to draw timber. In most of our mines we have properly qualified persons appointed to draw timber.

Mr. Binney—I agree with the President that we shall continue to have accidents, but I hope the number will be less than at present, and I think they may be much diminished. If all the so-called accidents were truly accidents, it would be presuming there was no carelessness or unskillfulness on the part of the men or the masters and officers who employ them. I think accidents can hardly be classed with carelessness. The President has compared a miner

with a sailor. Now the sailor can select his ship, and look at it before-hand; and he knows on what sort of a voyage he is going. He also knows that the Captain and Officers of a ship have been examined by a competent board, to ascertain that they are well-up in seamanship; and the sailor is aware that if they were not well-up in nautical matters they could not receive their certificates. With regard to officers of mines, I think that if they were examined respecting their knowledge of their work there would be great improvement amongst them. I think then that the comparison is not good, and the lives of colliers are certainly as valuable to the nation, every bit, as the lives of sailors. I am a small colliery proprietor myself, but there is no fire-damp in the whole district; and we have not occasion to take such precautions as are necessary in dangerous mines. My opinion is that, in the next twenty years the number of accidents will diminish very considerably. At the time mining inspection was first proposed, I did not think it would result in half the benefit it has done. Anyone who knew Lancashire twenty-five years ago must see that engineering and all operations connected with mining had greatly improved—in fact, more so perhaps than in any other part of Great Britain. The inspection of mines had been the means of sharpening-up people in the knowledge of their business; and although everything had not been done through the inspectors, still, a great deal of good had been accomplished by their agency. I will refer to one or two points in this paper. The remarks in connection with explosions are very singular. Mr. Warburton takes five years as they occur in the reports. It appears that in January only 40 accidents occur by explosion, while in February there are 174, and December 292. In December there is no particular atmospheric cause to account for the large number of accidents. True it is that at Christmas a great deal of coal is got out by the men to provide for the extra demand, and also with the view on their part to provide as much money as they can to spend in drink, &c., at the beginning of the New Year. An interesting point is the time of day when

accidents from the falls of roof occur. It is stated that most of these accidents occur late in the day. It appears to me that the collier when tired, and he wishes to leave, thinks that as the roof has stood so long it may stand a little longer. It is also a question whether a man after being in the mine for a long time has so keen a sense of apprehension of danger as at the beginning of the day.

The President—I do not wish to make any remark in favour of or against the value of mine inspections. The improvements noticed by Mr. Binney had been the improvements caused during the past twenty-five years by a desire on the part of capitalists and colliery proprietors to have better collieries than they used to have. It is probably also owing to collieries being deeper, and the difficulties to be encountered being more numerous, that proprietors were induced to have better machinery, &c. There are not more improvements in collieries than there are in mills. The mills of the present time are quite different to what they were twenty-five years ago; or I may refer to ships which are different to those built twenty-five years ago; and yet there is no inspection with regard to the construction of ships or mills. Although steam has been introduced into ships, no inspecting officer had been appointed. I therefore believe that the advancement or the improvement in the manner of conducting colliery operations are caused by the requirements of the age.

Captain Aitkin—I am not a practical miner, but having heard the observations of Mr. Goodwin, it strikes me that, with gas exuding, the intensity would increase after twelve o'clock in the day instead of decreasing, hence the accidents would be more numerous towards the end.

Mr. Goodwin—In many localities the men leave off work between one and two o'clock.

Mr. Chapman—Have we a single instance, Mr. Goodwin, where a large explosion has taken place, and when it has not been known to be from tapping fresh gas?

Mr. Goodwin—In the Lund Hill explosion we find from evidence that Mr. Coe, the manager, had refused to pass through one of the principal air-courses, owing to its being too small, and where 20,000 cubic feet of air should have passed. This explosion may be fairly attributed to the whole atmosphere of the mine becoming charged with gas, in consequence of defective ventilation.

Mr. Chapman—Have you ever seen an instance where the gas has fired from its coming out imperceptibly from a vein of coal?

Mr. Goodwin—If you put it in that form, I have never seen a case in which the gas might have been taken off. It might have been taken away by proper ventilation.

Mr. Binney—In all explosions there is too much gas and too little air. I think you may take that for granted.

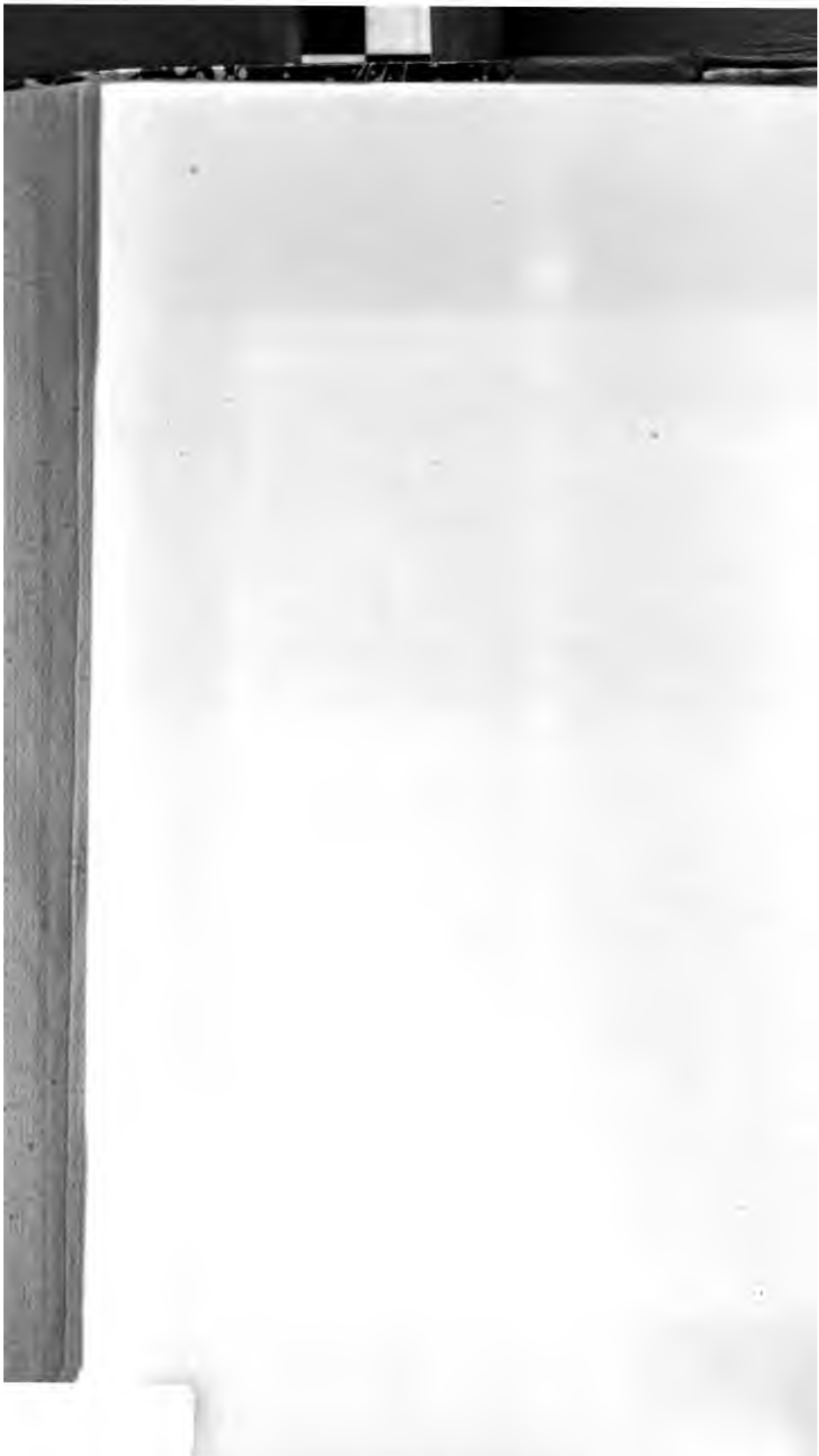
Mr. Baines—The want of attention to natural laws may account for these accidents; for I have often seen the cupola lower than the shaft instead of the contrary. The cupola and the mouth of the shaft should be after the form of a syphon. I believe there need not be explosions from fire-damp if there was a sufficient degree of draft, therefore it is only required that in connection with mining there should be a knowledge of the natural law—of pneumatics.

Mr. Binney—Our President says he does not think inspectors have had much to do with the improvements in mining. I do not want to give them more than their due; but still, I remember when I first came into Lancashire, it was common for workmen to test

places for gas by a lighted candle. In the early days of this society the men held their candles up and watched the flame rise. When they saw the flame extend, they trusted to cutting it off by their hand to prevent it from communicating with the fire-damp above, and thus causing an explosion.

Mr. Goodwin—In reply to Mr. Baines I may observe that the height of the cupola has very little to do with it in this immediate locality, inasmuch as in all well-conducted collieries we have powerful furnaces for the purpose of rarifying the air. I have conducted some hundreds of experiments, and the conclusion I have come to is that there is no universal law that can render us any material assistance. Many kind of accidents have been lessened of late years, but accidents from explosions and falls of roofs must continue so long as mining operations are conducted.

This concluded the discussion.



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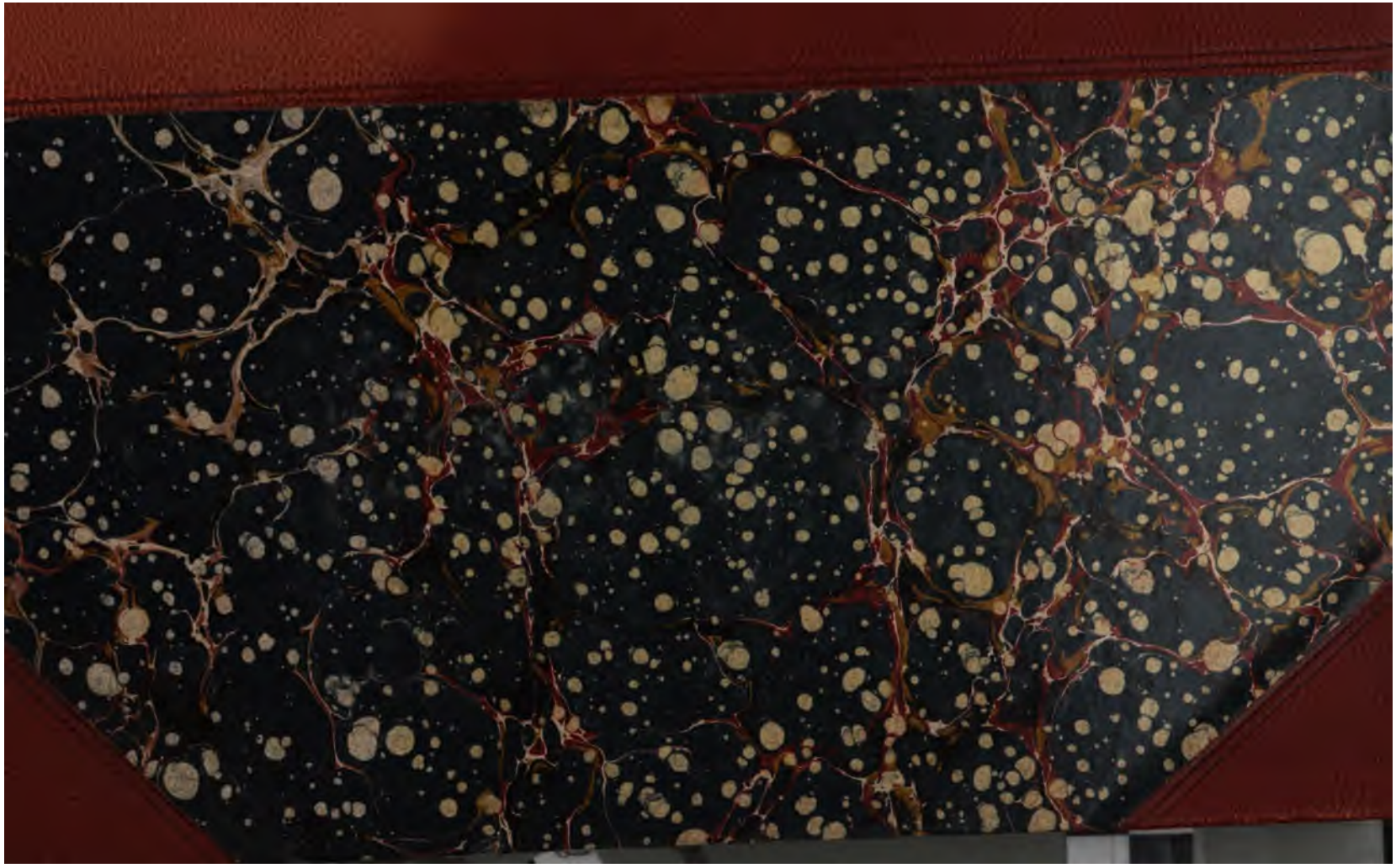
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